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THE CONTRIBUTION OF INVESTMENT AND SAVINGS TO PRODUCTIVITY AND ECONOMIC GROWTH IN CANADA

Working paper number 10
March, 1992

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WORKING PAPER SERIES

THE CONTRIBUTION OF INVESTMENT AND SAVINGS TO PRODUCTIVITY AND ECONOMIC GROWTH IN CANADA

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Working paper number 10
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EXECUTIVE SUMMARY

This paper addresses some fundamental questions concerning Canada's investment and savings efforts and their relationship to productivity and economic growth. Canadian prosperity depends on the level and quality of these efforts. Concerted investment and savings efforts can contribute directly to sustaining, or even improving, Canada's general standard of living and its internationally competitive position.

In all theories of economic growth, high efforts of investment, savings, and capital formation are associated with periods of high productivity and output. Investment provides the new capital — replacing the worn-out and discarded capital — necessary to increase the nation's productive capacity. This generates increased income and wealth, enabling more savings and investment, in a mutually reinforcing process. In addition, new investment brings more-productive technology, increased knowledge, and more-skilled labour into an economy.

A survey of investment and savings efforts among industrialized countries and Canada suggests that in the long run a correlation exists between investment efforts and productivity and economic growth. While cause-and-effect linkages between investment and savings efforts and productivity and economic growth are recognized, however, the relationships are complex, and the empirically derived linkages have not been as strong or direct as expected by economic theory, particularly in the 1970s and 1980s. Capital accumulation does matter for productivity growth, but innovation and other economic factors matter a great deal too. Other technological, physical, and human capital factors must be considered in order to explain fully the postwar experience. *The conclusion is that high levels of investment and savings efforts are necessary but not sufficient for good productivity and economic growth.*

Canada's postwar experience strongly suggests that the *quality* of investment is just as important as the *quantity*. Canada, along with other industrialized economies, failed to understand, or respond to, the complex ways that physical capital interacted with other economic factors. There are open questions about the pace of innovation and the appropriate mix of capital formation, and about the relationship of investment efforts to such factors as human capital and financial markets.

Looking ahead to the future, this paper convincingly demonstrates that *relatively small increases in productivity growth require substantial future investment efforts.* Moreover, it provides evidence that considerable additional investment and savings efforts are essential to solve infrastructure problems, overcome environmental degradation, reduce external debt, and meet the needs of an aging population. There

can be no one panacea for raising Canada's productivity and economic growth, but greater investment and savings efforts are integral and necessary parts of the multifaceted approach required to ensure Canada's future prosperity.

In examining a large body of empirical evidence focused on the past and future adequacy of Canadian investment and savings efforts, the following conclusions were reached:

- The overall growth of the Canadian economy exceeded that of productivity in the postwar period. More than in most other industrialized countries, Canada's rapidly expanding labour force was a major factor driving economic growth. As a result, a significant part of capital formation was destined simply to meet the demands of an expanding labour force. Consistent with the convergence theory, while Canada has narrowed its productivity gap with the United States, other industrialized nations have narrowed theirs even more. *Productivity growth* in Canada since the Second World War has remained consistently below that in the other G-7 countries, except for the United States. Among the industrialized countries, however, Canada's aggregate *level of productivity* ranks second only to the United States.

- The rate of Canadian productivity growth since the war shows three phases, similar in kind to, but different to a degree from, those of other major industrial countries. The trend rate of productivity growth was rapid in the "golden era" up to the early 1970s, slow between then and the early 1980s, and moderate (but still generally positive) in the 1980s. These phases of varying productivity growth for Canada occurred in labour productivity (total output per unit of labour input) and even more markedly in total or multifactor productivity (total output per unit of combined labour and capital). The *productivity slowdown* has taken place even though Canadian investment effort and the associated buildup of the stock of capital per worker in Canada have been well sustained in comparison with historical Canadian and international standards.

- Although the data are sensitive to methodological assumptions, there is disturbing evidence that Canada's level of manufacturing productivity is now lower than that of France, Germany, and Italy, and that the manufacturing productivity gap between Canada and the United States is no longer closing.

- The recent Canadian experience in manufacturing productivity and the modest growth of total factor productivity in the business sector of the economy suggest that Canada has a marked weakness in the so-called category of "innovation and other factors" as opposed to "investment per worker."

- Throughout the postwar years Canada achieved an *investment* effort comparable to the *average* among western industrialized nations. In the 1980s, Canada's relative investment effort rose to *above average*, partly because the investment efforts of other industrialized countries declined more. There is an established positive correlation between investment efforts and productivity and economic growth in the long run. The evidence on the abrupt productivity and economic slowdown that began in the 1970s, however, is a subject of debate among many analysts. Much of the economic growth in Canada and in other industrialized countries cannot be attributed to growth of labour and capital inputs; instead, it is due to increases in efficiency or productivity (the growth residual), which is the result of a complex myriad of other factors.

- The paper shows that Canada was the exception among six industrialized countries in the 1970s and 1980s, with investment per worker having marginally increased as labour productivity growth declined. This result supports the view that although weaker in the 1980s, capital accumulation has been relatively strong in Canada, while the intangible elements of total factor productivity growth — called innovation and other factors — have been a particular problem over the past 15 years.

- Canada's national savings efforts (i.e. savings rates in proportion to incomes) were lower in the 1980s than in the 1960s and 1970s. The trend rates of private savings by Canadians have been well maintained, more so than comparable rates in the United States. All Canadian governments taken as a group, however, shifted their position from net savers in the early 1970s to net dissavers in the 1980s. The overall shortfall of Canadian national saving below national investment in Canada was accompanied by a significant buildup of Canadian private and public external debt. The servicing of any specific amount of external debt is an even more serious problem than a comparable amount of internal debt, because Canadian *use* of real output has to be held below Canada's GDP. To control, and hopefully to reduce, the increasing burden of Canada's external debt, the national savings share of GDP will have to be increased. In regard to Canada's long-term investment needs, such changes deserve immediate concern.

- High levels of investment and savings are *necessary* for productivity increases and sustained economic growth. More recent economic theories serve to reinforce this point by stressing the significance of spillovers related to investment and savings. Innovation and other factors explain most of the productivity slowdown of the 1970s and 1980s, however — not the level of investment per worker. Even the latest studies of economic development conclude that much more research is required to determine the precise role of innovation and other factors. For Canada, the main contributors to the productivity growth slowdown appear to have been: the exhaustion of pools of underexploited knowledge available

immediately after the war; the emergence of non-tariff trade barriers; the changing labour force composition and growth, which led to fewer opportunities for expansion; the deterioration in Canada's terms of trade; the costs of maturing social programs; Canada's poor record in fighting stagflation; and the instability of the international monetary system. In Canada, there appear to be particular problems with machinery and equipment investment. Although it was relatively high in the 1980s, machinery and equipment spending has not yet translated into the innovative practices that are traditionally expected to contribute directly to productivity growth.

- The postwar experience in Canada suggests that a main lesson from the past concerns the *quality* of investment efforts. There are open questions about the pace of innovation and the appropriate mix of capital formation. Crucial has been the way in which physical capital interacted with other economic factors, such as human capital, the innovation process, unproductive elements of the capital stock, and financial markets. Nevertheless, it is clear that a good level of investment in fixed capital is essential to productivity growth. That is so, given Canada's rapidly expanding labour force and its unique economic features. Canada's geography, climate, capital-intensive industrial structure, and population reflect the need for a relatively larger investment effort than in many other industrialized economies.

- Quantitative analysis, extrapolating the most reasonable estimates of labour growth, productivity, and capital/output ratios, and their impact on net and gross investment needs, clearly indicates that even under the most modest productivity estimates, relatively small increases in productivity growth require substantial future investment efforts. The three estimates of future gross investment efforts range from a low of 20.6 percent, to 23 percent, to a high of 26.9 percent of current GDP. All three estimates are predicated on projected growth in the labour force of 1.4 percent and productivity increases consistent only with the sluggish levels of the last decade. These estimates do not put Canada on a productivity and economic growth path as high as that of the golden postwar years. Moreover, they do not consider any significant changes in the quality of capital as a result of technological change and innovation.

- Despite these modest growth and productivity assumptions, the middle and the high estimates seem optimistic in terms of Canada's historical investment, which averaged a bit above 23 percent between 1955 and 1980, and under 23 percent in the 1980s. The low estimate appears unacceptable, since it allows for productivity growth below the levels of 1988 and 1989.

- Looking ahead it is almost certain that additional investment and savings efforts are essential to solving infrastructure problems, overcoming environmental degradation, achieving sustainable growth, reducing external debt, and meeting the

needs of an aging population. These are areas where real pressures for more investment exist, even given opportunities to meet investment demands in more efficient ways. They can only be successful, however, if they are part of a *multifaceted* set of economic policies designed to increase Canadian potential, innovation, work skills, capacity utilization, and market access. The relative importance for Canada of the other intangible economic factors and innovative practices makes this unavoidable.

- There are still some gaps in the story. The data measuring national output, capital flows, investment flows and total factor productivity have been significantly revised recently by Statistics Canada, and these data revisions are not incorporated in this paper. Analysis shows that the conclusions herein are not changed; however, many of the quantitative relationships are affected. Three of the principal revisions involve a drastic re-evaluation and ensuing reduction in the lives of capital assets; a new set of price indices for use in converting current- to constant-dollar investment in machinery and equipment, and construction; and a rebasing of constant-dollar national accounts data from 1981 to 1986, based on new weights and prices. While these changes account for more relevant estimates of the value of today's capital stock, they present a dilemma regarding their application to earlier stocks. For example, major changes in technology have affected computer power. How can substantially decreased prices for more powerful computers be reflected in the capital stock figures for the 1960s and 1970s?

- Interest has arisen in a new economic-growth theory, whereby Canada's performance is examined in a different light, especially during the postwar period. The new theory treats technological change as endogenous to economic growth rather than as an exogenous factor. The phenomena of capital deepening and widening and their relationship to technology are questions addressed by the new growth theory. The roles of investment and savings take on added importance in the productivity story in many such new theories.

- Total factor productivity (TFP) is a derived measure — a residual calculated by subtracting the contributions of labour and capital from overall productivity. Total factor productivity represents the contribution of technology and other factors to overall performance. In analyzing the record of productivity and growth trends, there is extensive room for explaining such a residual composed of a multitude of factors. The complexity of these factors and their interrelationships continue to plague the science of economics. For example, there remains considerable difference of opinion on the residual factors and their presumed importance

before and after 1973. The challenge, therefore (if we are to understand the multifaceted productivity story), is to make some real progress in the methodology used to derive TFP and in its interpretation. Canadians, like researchers in other industrialized countries, still have much work to do.

In summary, ensuring both a higher level and better quality of investment and savings efforts is the fundamental economic challenge facing Canada in the 1990s. Such efforts are absolutely essential to sustaining, or even increasing, productivity and long-run economic growth. Future Canadian prosperity and standards of living depend on it.

INTRODUCTION

This paper addresses three fundamental questions about the adequacy of Canada's investment and savings efforts.[1]

- *Have weak Canadian investment and/or savings efforts been a major factor in the unsatisfactory Canadian productivity growth of the past 15 years?*

- *Could stronger Canadian investment and/or savings efforts improve our future productivity performance and ability to realize other goals?*

- *Are additional investment and savings efforts essential to solving infrastructure problems, overcoming environmental degradation, achieving sustainable growth, reducing external debt, and meeting the needs of an aging population?*

In all theories of long-run economic growth, high efforts of investment, savings, and capital formation are associated with periods of high productivity and economic growth.[2] Investment provides the new capital — replacing the worn-out and discarded capital necessary to increase the nation's productive capacity. This generates increased income and wealth, permitting more savings and investment, in a mutually reinforcing process. In addition, new investment brings more-productive technology, increased knowledge, and more-skilled labour into the economy.

Serious concerns have been expressed in international circles about the adequacy of national savings and investment efforts in western industrialized countries generally [see, for example, Dean *et al.*, IMF, World Bank, and de Vries].[3] For many western industrialized countries, including Canada, savings and investment constituted a smaller

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[1] We especially thank Mike McCracken and Ian Stewart for their comments upon reviewing an early draft of this paper.

[2] Appendix A provides a brief explanation of the underlying concepts of investment, savings, capital, productivity, and economic growth. Appendix B discusses the theory of capital formation, economic growth, and productivity. Appendix C outlines the significance and measurement of productivity.

[3] In this paper, because of the number of other researchers referred to, we have chosen to show in the text only the name (or surname) of the author of a publication (plus the date if an author has more than one work listed). The reader is invited to go to the Bibliography at the end of this paper for full details regarding each reference cited herein. The term "western industrialized countries" is used here in a generic sense to refer to the G-7 countries and others such as Australia, Belgium, Denmark, Ireland, Greece, the Netherlands, and Norway. The sources cited in this study base their observations on varying groups of these countries.

proportion of GNP from the mid-1970s through the 1980s than in the preceding 25-year postwar period. Productivity growth was also slower in many countries, and most medium-term forecasts indicate that future productivity growth will remain below the rates of the 1960s. Overall economic growth also slowed down.

To address these questions, Canada's experience is considered in relation to other industrialized countries and in light of its own unique investment and savings attributes. It is important at the outset to remember that the Canadian economy is not simply a microcosm of an OECD average. It has particular investment and savings attributes as a result of its geography, climate, capital-intensive industrial structure, and population. This is perhaps nowhere more evident than when judging Canada's future capital needs.

The answers to these questions are essential to understanding the complex nature of the fundamental economic challenges facing Canada in the 1990s. Canadian prosperity depends on the level and quality of investment and savings efforts. These efforts are fundamental prerequisites for productivity and economic growth. High investment and savings efforts can contribute directly to sustaining, or even improving, Canada's general standard of living and its internationally competitive position.

The first chapter of this study looks at international trends in productivity and economic growth since the 1950s, and the accompanying trends in investment and savings. Only western industrialized countries, the G-7 group, and the other larger OECD group are considered. The second chapter looks at the particular features of the Canadian experience since the 1950s. Canada's productivity and economic growth are examined, followed by a review of its investment and savings record.

The third and fourth chapters address the adequacy of Canada's past and future investment and savings efforts. The third chapter examines the past Canadian experience in terms of such issues as investment and the capital stock; savings and the role of foreign capital; the pace of innovation; and the mix of capital formation. Most importantly, it considers productivity and its link to other factors in Canada. The purpose is to determine the adequacy of the past levels and uses of investment and savings.

The fourth chapter reviews Canada's future needs for investment and savings. Using estimates of incremental investment as a percentage of GDP, the investment and savings efforts needed to equip the growing labour force to achieve modest productivity growth, and then to increase the capital/output ratio, are calculated. The focus of this analysis is the extent to which stronger investment and savings efforts are required, and the sensitivity of those requirements to changes in productivity goals. Finally, to examine the more-qualitative aspects, Canada's ability to provide the additional resources needed to meet its future infrastructure requirements, its environmental protection goals, the needs of an aging population, the reduction of external debt, and so on, are discussed.

The fifth chapter deals with methodological issues and opens questions that require further work to improve the understanding of Canadian economic growth. Lively and important debates are now under way in Canada, but even more so in the United States and Europe, about the data, the relevant theories, and the implications for policy. Of particular concern are the new (or substantially revised) theories of growth and international trade, industrial organization, and the relationships between activities at the level of firms and industries and the aggregate productivity measurements.

The sixth chapter outlines the conclusions reached in the study.

CHAPTER 1
Trends in Western Industrialized Countries

TRENDS IN WESTERN INDUSTRIALIZED COUNTRIES

This chapter reviews the postwar experience of productivity and economic growth shared by the industrialized countries, as well as the related investment and savings patterns up to the late 1980s. During this period, the western industrialized countries recorded high and sustained economic growth through comparable increases in productivity. Sustained growth of an economy's standard of living can only be achieved through increases in its productivity. Living standards can increase temporarily from a rise in the size of the labour force or when resources are diverted from savings to consumption. In contrast, when workers produce more with a given effort (i.e. when lasting improvements in productivity take place), individuals can expect to achieve a permanently higher income.

Productivity and Economic Growth Trends

Many papers and books have analyzed the postwar productivity and economic growth experience. Analysts often disagree as to its measurement, the root causes of change, and the impact of policies. Moreover, judgments can differ over how variations among countries reflect unique conditions and national patterns. Nevertheless, analysts do agree on some common international causes and processes that suggest strong similarities across industrialized countries. Related to this shared experience is a fundamental debate concerning economic leadership and which countries are ahead in the productivity and economic growth race.

Since the Second World War, western industrialized economies have experienced the largest and most widespread economic growth and productivity gains in modern history. But for most countries, the "golden age" of strong growth in productivity and output between 1950 and 1973 was followed by a relatively abrupt slowdown in the mid-1970s and by slower but positive growth thereafter and throughout the 1980s [see IMF; World Bank; Boltho; Maddison (1979, 1980, 1984); and Rao and Lemprière].

The record also shows that among industrialized countries there have been some notable dynamic performers, particularly Japan and Germany. Some analysts make a great deal of these performers and suggest that the marked differences in the relative rates of productivity and economic growth are cause for alarm in such countries as the United States and Canada - countries that have been the postwar leaders in terms of productivity levels. This view stresses that not only has the productivity growth of the United States and Canada been considerably slower than that of a number of other industrialized countries, but the shortfall has persisted for some time [see Baumol *et al.*].

There is, however, another way of looking at these developments that suggests a much less alarming scenario. Many analysts agree that the postwar western industrialized economies have closed historical gaps in the levels of productivity [see, for example, Maddison (1979, 1980); Rao and Lemprière; Boltho; Bureau of Labor Statistics; and Baumol *et al.*].[4] This interpretation of the record is called the *convergence theory*. It asserts that economic forces are enabling other countries to catch up to the leader but not necessarily to surpass it.

The central argument of the convergence theory is built around the leader - the United States - and the followers (the other western industrialized countries), which catch up by exploiting the knowledge available from the leader. The leadership, in the case of the United States, involves technical progress, the elimination of trade barriers, market development, and outward direct investment by its firms. The record shows that economies such as those of Germany, France, and Japan started out in the postwar period with low levels of productivity compared with that of the United States, but it is those countries that experienced the most rapid growth in productivity and output. Those, like Canada, which started the postwar period with levels of productivity closer to that of the United States, have had less rapid growth, although even Canada did narrow its productivity gap with the United States during the postwar period [see Maddison (1979, 1980); and Rao and Lemprière]. As the productivity gap with the leader has narrowed, so have the growth rates of Germany, France, and Japan relative to the United States and Canada.

The convergence theory raises other important issues. It is one thing to catch up to a leader and quite another to become and remain a leader. Leading appears to involve much higher costs and risks than does following. Will Germany and Japan become leaders in productivity levels in sufficient types of goods production to become the overall leaders, replacing the United States? What about the leadership in tradeable service industries, which are of increasing importance in overall production and trade?

The convergence theory does not explain the abrupt productivity and output slowdown common to all the industrialized countries in the 1970s and 1980s. The convergence trends continued, but the absolute rates of increase in output and productivity were reduced in all of those countries, albeit to somewhat differing degrees. To explain the more or less simultaneous slowdowns, one has to look to massive changes in the supply of, and demand for, various goods and services, and to financial and fiscal

[4] Evidence relating to the theory is contested. The U.S. Bureau of Labor Statistics, however, shows that from 1960 to 1973 the growth in manufacturing output per hour in Japan was 7 percent higher than in the United States, while from 1973 to 1989 the difference was only 2.8 percent. Similarly, from 1960 to 1973 this same measure was 2.4 percentage points higher in Germany than in the United States; from 1973 to 1989 there was no difference between the two countries.

relations. The differing international reactions to the stagflation of the 1970s and 1980s were the key.

- Although unemployment rates varied considerably within and among the western industrialized economies, they generally averaged higher after 1975 than in the years before.

- It is harder to generalize about capacity-utilization rates because they are defined and measured in such diverse ways. Some measures, however, indicate lower average capacity-utilization rates in the late 1970s and 1980s than in the 1960s and early 1970s.

- Inflation rates were low in the 1950s and 1960s; however, they exploded to historically high rates in the 1970s and early 1980s. They declined though in the latter part of the 1980s, ranging between 3 and 5 percent.

In fact, these variations in rates are less puzzling than stagflation and its resulting asymmetries, stagflation being the combined effect of these short-run phenomena. In many economies, historically high rates of inflation existed simultaneously with high rates of unemployment and low levels of capacity utilization. The ratios of job vacancies to unemployment increased [see Economic Council of Canada (1982, 1988)]. Measurements of the non-accelerating inflation rate of unemployment (NAIRU) trended upwards in the industrialized economies [see Rose]. Inflation rates tended to accelerate even when moderate capacity-utilization rates appeared; but as capacity-utilization rates fell, inflation rates did not decelerate at a comparable pace [see Purvis].

Put rather bluntly, *all* western industrialized economies have failed to combine low unemployment rates, high capacity-utilization rates, and low inflation. That is just as true for the more dynamic countries, such as Japan and Germany, as it is for the traditional leader, the United States.

The inadequate response to the stagflation experience is considered by many to explain some of the productivity and economic slowdown in the 1970s and 1980s, but the issue is how much. It is widely agreed that higher average degrees of slack (unused productive capacity) were a factor in productivity being below potential, and in slower productivity growth trends after 1975. This slack could have resulted from market imperfections, business cycles, or structural changes, such as the transition to a more service-based economy.

Analysts disagree, however, about the significance of slack for productivity growth trends. For example, John Helliwell has argued that it was a major factor, accounting almost entirely for the productivity slowdown; others, such as Gerald Stuber and the Macdonald Commission, considered slack to be a minor factor.

Thus, among the western industrialized economies, the golden age of postwar growth was followed by a relatively abrupt slowdown in productivity and economic growth, beginning in the mid-1970s. Relative to other countries, Japan and Germany have been dynamic performers, but there is evidence of convergence in the growth and level of productivity and output continuing among the western industrialized countries. The abrupt slowdown common to all industrialized economies reflects to some degree the problems encountered with stagflation. The fact is that during the 1970s and 1980s no industrialized country successfully combined low unemployment rates, high capacity-utilization rates, and low inflation.

Investment and Savings Trends

Theories

Theories of capital formation and growth are sketched in Appendix B. These theories suggest the following expected relationships between economic factors in western industrialized countries over the postwar years.

Historically high efforts of investment, savings, and capital formation should be associated with the golden period of growth from 1950 to 1973; lesser efforts, with the slower growth trends from that point onward. Countries that ranked high in economic and productivity growth should show relatively larger investment efforts than those that ranked low.

If investment efforts were smaller from the mid-1970s for western industrialized countries, savings efforts should also be smaller. That relationship, however, must be qualified by exports and imports of savings to and from the eastern and Third World economies. Since savings can be imported and exported *among* the western industrialized countries, a weaker positive correlation should be expected between the ranking of countries in growth and in savings efforts than between growth and investment effort.

International competition for markets has intensified in recent years. The globalization of knowledge, communication, and capital flows has intensified, and technologically sophisticated goods and services can be produced effectively in many places. Yet competition has been blunted by the increased use of non-tariff trade barriers. Investment efforts in economies can therefore be expected to be even less directly related to savings efforts, suggesting a weakening in the correlation between domestic investment and savings rates.

Rostow suggests that once an economy reaches the stage where economic growth is sustainable, it can "take off", because its sustainable growth path consistently leads to higher standards of living. Consistent with the convergence theory, those economies that

do take off should close their productivity gaps with the leaders. At the same time, productivity leadership should become more widely shared among the technologically advanced countries with high levels of education, foreign investment, research, and the adoption of innovations.

Countries that have depended heavily on foreign savings are expected to build real debt-service burdens that will strain their income and export positions. Such an outcome is not certain, but there are many modern examples of such results. Adverse outcomes are more likely when the incremental use of foreign savings is directed towards more consumption than investment, although wasteful and inefficient investment projects can also have a negative impact.

Another important issue raised by recent theories of economic growth concerns the possibility of a substantial gap between the private and social returns to saving and investment. If there are technological externalities or increasing returns associated with the production of capital goods, then the social cost of foregoing increased investment may be very large.

Evidence

A considerable number of studies of the investment/productivity relationship exist. The strength of the relationship has been well established over the long run. Many analysts have focused, however, on the sources of the productivity-growth slowdown in the 1970s and have tried to determine the contribution that savings and investment made to it. In general, the studies show experience consistent with theoretical expectations, although the evidence is somewhat less supportive of the theories than perhaps desired. For that period, some find a weak correlation between investment and productivity growth. The linkages are less strong, indirect, and more complex than postulated. This complexity has led some analysts to examine the fundamental issue of the role of capital formation in the mechanics of productivity growth.

For western industrialized countries as a whole, investment and savings efforts were high by historical standards throughout the postwar period, but relatively lower in the late 1970s and the 1980s. Investment efforts dropped after the initial oil price shock in the 1973-74 period, but they still remained quite high by historical standards [see Maddison (1979, 1980); Boltho; and OECD]. The stocks of plant and equipment, and housing, continued to grow faster than populations and labour forces. Savings efforts in many countries decreased more than investment efforts. This was due mainly to reduced government savings (that is, increased government "dissavings" through higher deficits and debt) rather than lower private savings efforts.

The International Monetary Fund's *World Economic Outlook* for 1989 shows that in the aggregate the slower overall growth and productivity increases since 1975 are

correlated with a reduction in the rates of both gross investment and gross savings (see Table 1-1).

Table 1-1
Investment and Savings for All Industries in Industrialized Countries, Selected Periods, 1970-88

Percentage of GNP	1970-73	1975-80	1983	1984-88
Investment	24	23	20	21
Savings	25	23	19.5	20

Source: International Monetary Fund, *World Economic Outlook* (Washington: IMF, 1989), Chart 20.

The paper by Dean *et al.* covers trends in the OECD countries for the period from 1960 to 1988.[5] The conclusions reached shed light on the theoretical expectations explained above and on the strength of the correlation between slower growth and weaker investment and savings efforts.

- Chart 1-1 shows that the national savings and investment rates in most OECD economies declined between 1960 and 1988. For the OECD area as a whole, the average ratio of current-dollar gross national investment relative to GNP declined by about 2 percentage points, from about 22 to 20 percent. The ratio of gross national savings to GNP fell by 3 percentage points, from close to 23 to 20 percent.[6]

- The largest drops in investment and savings occurred in continental European countries and Australia, while the smallest changes were in the United Kingdom, Canada, Finland, Ireland, New Zealand, Norway, Portugal, and Switzerland. Despite the relatively small changes in the United States, a marked gap between investment and domestic savings emerged in the late 1980s.

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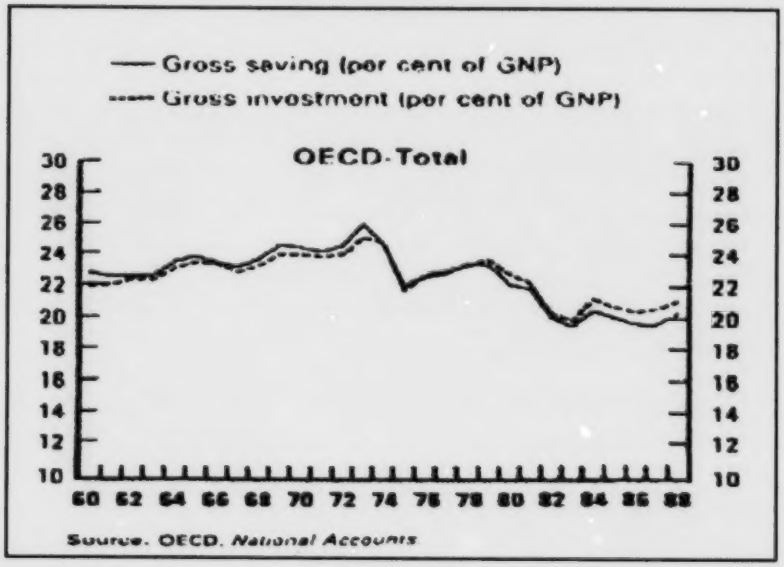
[5] Appendix D details their findings with reference to Chart D-1, "Trends in National Savings and Investment Rates, G-7 and OECD Countries, 1960-88"; and Table D-1, "Net and Gross National Savings Rates, OECD Countries, 1960-88."

[6] The investment effort measured in constant dollars differs from that measured in current dollars. Since current-dollar investment in computing has been a relatively large component in recent years, and since the price and cost of given standards of computing have fallen rapidly, productivity measures have been underestimated. At the same time, the constant-dollar measurements of investment relating to computers is likely underestimated. Accordingly, a special deflator that takes these facts into account needs to be developed and refined.

Chart 1-1
Trends in National Savings and Investment, OECD Total, 1960-88



- Table 1-2 shows net and gross national savings rates for the average of the OECD countries (excluding Italy). Note that while both gross and net savings fell, the rate of decline was less for the gross measure. This is primarily the result of relatively greater depreciation, which affects the calculation of net savings.

Table 1-2
Net and Gross National Savings Rates, OECD Average,* Selected Years, 1960-88

Savings rate	Averages			1986	1987	1988
	1960-70	1971-80	1981-88			
Net	14.6	13.5	8.7	8.2	8.2	9.3
Gross	23.3	23.5	20.2	19.6	19.6	20.3

*Excluding Italy.

Source: Estimates by Andrew Dean, Martine Durand, John Fallon, and Peter Hoeller, in "Saving Trends and Behaviour," *OECD Economic Studies*, no. 14 (Paris: OECD, 1990), based on OECD, *National Accounts*.

- The strong correlation between national savings and investment rates, identified for early periods by the likes of Feldstein and Horioka, was substantially reduced in the later period.

- The reductions in government savings since the 1960s were an important factor, along with the decline in national savings and investment.[7]

- Private sector savings rates exhibited greater stability over time than the components of household and business rates.

- Business savings were strongly related to profit developments. The sharp recovery in profits since the early 1980s has boosted business savings and considerably increased the self-financing of business investment. In fact, business investment as a percentage of GDP increased sharply in the 1980s in all OECD countries [see Ford and Poret].

- Household savings ratios rose almost everywhere in the 1970s. In the 1980s they declined markedly in almost all countries, reaching levels similar to those in the 1960s or even lower. The 1970s "bulge" in savings ratios is less significant when adjusted for inflation.

- Tax structures were an important influence on household savings decisions and in many cases led to important distortions.

What do these patterns suggest for the relationship between investment and savings efforts and the productivity slowdown? Boltho, after comparing productivity trends and investment ratios for 14 European countries from 1953 through 1979, argued that "investment ratios declined virtually everywhere in the post-1973 world . . . and this, no doubt, reinforced the productivity slowdown" (pp. 22-23). He also showed a positive correlation between investment efforts and GDP growth among the European economies.[8]

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[7] This relationship is partly causal and partly incidental. The relative increase in government deficits has been large - a factor lying behind high interest rates, which in turn discourage investment. High interest rates encourage private savings, however, and private savings efforts were high by historical standards. When reckoning national savings, the increase in government deficits has been deducted from private savings. In many western industrialized countries, these increases in government deficits have outweighed any changes in private savings.

[8] Boltho later examines the causes of the decline in the investment ratio, and this matter is discussed below.

Maddison, in his paper on the *Long Run Dynamics of Productivity Growth*, reports (p. 18) that "the fundamental instrument (on the supply side) for faster postwar productivity growth has been the acceleration in growth of the capital stock per hour worked." Maddison reached this conclusion with reference to the historical record of the growth of non-residential fixed capital stock per person-hour for the G-7 countries. His data have been reproduced in Table 1-3. He suggests that the data demonstrate:

> that, on average, the growth of capital stock per hour worked since the Second World War has been three times as fast as in the previous 80 years. This postwar acceleration did not occur in the U.S.A. There is a rather striking degree of parallelism in the productivity and capital stock per man hour record in the long run.

On the particular matter of the role that investment and savings played in the productivity slowdown of the 1970s, however, Maddison was more circumspect. He concluded that "except in Canada and the U.S.A., the capital stock per man hour rose faster in the 1970s than from 1950 to 1970 . . .. Hence, recent developments in the capital stock do not do much to explain the productivity slowdown in the 1970s, except in Canada and the U.S.A."

Table 1-3
Growth of Fixed Business Capital Stock per Person-Hour, G-7 Countries, 1870-1977

	Average annual compound growth rate (average of gross and net stocks)			
	1870-1913	1913-50	1950-70	1970-77
Canada	n.a.	1.8[a]	3.6	2.7
France[b]	n.a.	(1.8)	5.2	8.0
Germany	(2.1)	(0.9)	5.9	7.1
Italy	[2.3][c]	[2.6]	[4.9]	[7.3]
Japan	2.0[d]	[2.9]	6.8[e]	8.4[e, f]
U.K.	0.6	0.8	4.0	4.4
U.S.A.	2.6	1.8	2.7	1.8
Average	1.9	1.8	4.7	5.7

Note: All figures are adjusted to eliminate the impact of geographic change. Average is calculated on an arithmetic basis. Figures in round brackets refer to net stock only; figures in square brackets, to gross stock only: [a]1926-50; [b]refers to private stock; [c] 1882-1913; [d]1880-1913; [e]net stock refers only to the private sector; and [f]1970-76.

Source: Angus Maddison, "Long Run Dynamics of Productivity Growth", *Banco Nazionale del Lavoro Quarterly Review*, no. 128, March 1979.

Baumol *et al.*, in *Productivity and American Leadership: The Long View*, address the investment/productivity linkages with reference to the mechanics of productivity growth. They review empirical evidence on the course of total factor productivity and its relation to labour productivity for a number of countries and for relatively long time periods since the nineteenth century. The postwar experience is therefore a relatively short interval in a long-term context.

They set out the relationship between TFP and labour productivity growth as follows [see also Appendix C]. Broadly, TFP growth is defined (p. 165) as the enhanced production attributable to improvements in the efficiency of all inputs combined and not just labour alone. It is measured as the part of a country's output growth that is not attributable to mere increases in the quantities of inputs such as labour and capital. Total factor productivity represents the share of output attributable to innovation and other influences that enhance the productivity efficiency of those inputs. In contrast, labour productivity growth is said to depend primarily on two influences - innovation and investment per worker. Thus the authors stress that information on TFP growth serves to indicate what portion of labour productivity growth is attributable to innovation; it also reveals residually how much of the labour productivity growth can be ascribed to investment per worker.[9]

Based on their own evidence and that of Abramovitz and David, Baumol *et al.* suggest that TFP growth has generally been significant for western industrialized countries and, except during wars and depressions, rather persistent for at least the past 11 decades. They also show that TFP growth has generally been quite a bit lower than the overall rate of labour productivity growth. Baumol *et al.* conclude therefore that *capital accumulation does matter for long-run productivity growth; but other things, notably innovation, matter a great deal too.*

It is important to note in this first chapter one issue relating to savings and investment that became of great concern to analysts during the 1980s. Although it is not analyzed in detail in the context of this paper, it is relevant to subsequent analysis. The issue is that of increased reliance by the United States, Canada, and Australia on foreign savings, suggesting a gap between investment demand and domestic savings. For example, papers by Marris and de Vries have sounded this alarm loudly for the United States.

> [Marris]: This study sets out the reasons why, on present policies, a hard landing has become inevitable for the dollar and the world economy. The dollar will, over time, go down too far, and there will be an unpleasant world recession (p. iv). . . . The right answer to the present disequilibrium in the world economy is to correct its basic cause: the divergent trend in

[9] For Canada, these relationships and related quantitative measurements are set out in Statistics Canada, *Aggregate Productivity Measurements* (Ottawa: July 1991).

> investment demand and domestic savings in the United States and the rest of the world (p. lxiv).
>
> [de Vries]: Yet, just as complacency following the first oil shock proved unjustified, so too is complacency foolhardy today. The world economy may have suffered excess saving relative to investment opportunities during much of the 1980s; and the risk-reward characteristics of investment may still be perceived as more attractive in the U.S. economy than elsewhere. But neither condition can be extrapolated forever. U.S. inflation remains stubborn and the economy soft, whereas most other industrial economies now operate at fairly full capacity. New demands are coming along from Eastern Europe and, to a modest extent, Latin America, to which some flight capital is returning. Amid these rival claims on foreign saving, financing of the U.S. twin deficits could grow steadily more costly. . . . Domestic and external adjustment cannot be avoided, but only postponed. If postponed too long, the adjustment can be abrupt, wrenching, and protracted: for the debtor, bringing loss of access to credit, inflationary depreciation, and economic slump; for the investor, leaving uncollectible claims and collapsed asset values (pp. 8-9).

Many analysts have discussed the nature and implications for the United States and Canada of their dual deficits (in balance of payments and government expenditures) [see World Bank].[10] Suffice it to say that the balance-of-payment deficits do not in fact result from unusually large investment efforts; rather, they reflect smaller domestic savings efforts, mainly because of the increased size and persistence of government deficits.

In conclusion, the weight of evidence in studies of the postwar experience of western industrialized countries demonstrates a highly probable cause-and-effect linkage between investment and savings efforts and long-run productivity and economic growth. There is some disagreement among analysts, however, about the role that investment and savings played in the productivity slowdown of the 1970s. While there is no doubt that capital accumulation was important, the other intangible elements of productivity growth, called innovation and other factors, mattered a great deal too. It is important to remember in this context that the term *innovation* is used in a broad sense, involving not only technological change, but institutional, marketing, and human capital factors as well. The evidence is therefore characterized by more complex, indirect, and less strong relationships than suggested by theory.

[10] A related issue that might be considered in this context is that of the imbalances in Third World debt. This issue is not examined here.

CHAPTER 2
Trends in Canada

TRENDS IN CANADA

This chapter examines the Canadian record. While the overall productivity and economic growth performance of the Canadian economy has been similar to that of other industrialized economies, the Canadian experience is unique in a number of ways. The differences in productivity performance relative to other countries need to be singled out, as they are at the heart of concerns about Canada's international competitiveness. These differences include the strong rate of labour force growth, the poor record of labour productivity in manufacturing during the postwar period, and the negligible TFP growth in the 1980s. In the same vein, the following also sets out the Canadian investment and savings experience, comparing it with other industrialized economies and identifying its detailed domestic characteristics.

Productivity and Economic Growth Trends

The long-run trend of productivity growth in Canada, as in other industrial countries, was faster between 1950 and 1973 than between 1973 and 1988 [see Swimmer (1989); Rao and Lemprière; and Bureau of Labor Statistics, U.S. Department of Labor]. Historically rapid growth was followed by a long period of slower growth, characterized by stagflation. It is difficult to determine how much of this rapid growth was postwar "catch-up" and how much was the result of new, favourable, long-run growth factors such as reductions in trade barriers. The consensus of economic historians and analysts is that both factors were at play.

Canada, like other industrialized countries, has had short-run variations in productivity and economic growth around these general patterns. Growth was relatively slow between 1957 and 1962 and exceptionally rapid between 1966 and 1973. The 1981-82 recession was more severe in Canada than in most other industrialized countries. In comparison with earlier Canadian experience, as well as the contemporary experience of other western industrial economies, Canadian productivity growth was relatively sluggish in the 1980s.

Table 2-1
Real Gross Domestic Product per Capita and per Employed Person: Other G-7 Countries Relative to Canada, Selected Years, 1950-89

	Canada	U.S.A.	Japan	Germany	France	Italy	U.K.
Real GDP per capita							
	(1989 US$)	Comparison (Canada = 100)					
1950	6,926	144.0	23.2	51.9	63.9	45.6	87.0
1960	8,322	138.9	40.0	84.9	75.6	62.4	92.4
1970	11,545	128.0	71.4	86.9	84.3	73.3	83.0
1975	13,976	111.6	67.5	78.0	79.6	67.2	75.7
1980	15,999	108.6	71.8	80.7	79.3	72.8	71.9
1989	19,679	106.2	80.0	77.3	74.4	71.4	72.9
Real GDP per employed person							
	(1989 US$)	Comparison* (Canada = 100)					
1950	18,972	131.6	20.0	45.3	50.1	38.6	70.8
1960	24,137	126.8	29.5	62.3	60.3	52.9	69.1
1970	30,693	120.6	55.1	74.7	77.0	76.0	70.3
1975	33,877	112.9	60.0	77.3	80.8	77.9	70.5
1980	35,679	109.3	68.5	84.8	87.7	89.4	72.7
1989	41,066	106.3	77.3	87.2	91.4	92.8	76.0

*Based on purchasing-power parity rates, disaggregated by major industry.
Source: Estimates by P. S. Rao and T. Lemprière, based on unpublished data from the U.S. Department of Labor, April 1990.

Table 2-1 sets out the record of Canadian overall labour productivity, judged in terms of GDP per employee, relative to the other G-7 countries. Consistent with the convergence theory, Canada entered the postwar period with a level of productivity well below that of the United States; however, it was closer to the U.S. level than any of the

other G-7 countries or western industrialized economies.[11] Canada has narrowed its productivity gap with the United States, but other countries have narrowed their gaps even more. Thus the trend lines of Canadian productivity growth since the Second World War have remained consistently below those of the other G-7 countries, except for the United States.[12]

Labour force growth has been a major factor driving Canada's economic growth, and this has direct implications for its productivity record relative to other countries. It is important to remember that Canada has had much more rapid growth in its labour force than most other industrialized countries, including the United States. Consequently, while output in terms of GDP per capita has grown very fast, growth in productivity, judged by GDP per employee, has been less impressive. This means that relative to other countries, Canada's investment efforts have been dedicated more to so-called "capital widening" than to "capital deepening". That is to say, relatively more investment has been attributed to equipping new entrants to the labour force with about the same amount of capital per worker as that already existing for the labour force in general.

There are disturbing signs that Canada may be on a unique path in the area of manufacturing productivity. Table 2-2 shows Rao and Lemprière's Economic Council of Canada data comparing Canadian manufacturing labour productivity with that of other G-7 countries. It clearly reveals that between 1951 and 1980, Canada succeeded in substantially narrowing its manufacturing productivity gap with the United States. Since 1980, however, the situation has worsened. Moreover, Table 2-2 indicates that France, Germany, and Italy - countries whose manufacturing productivity levels in 1951 were about half as high as Canada's - had all passed Canada by 1989. The Japanese level of manufacturing productivity has also grown remarkably since 1951, and it is conceivable that Japan will surpass Canada in the next decade.

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[11] This is also shown by Boltho and Maddison. As discussed earlier, Boltho compares 14 European countries, using GDP per employee for the whole economy as the measure of productivity level. Maddison (1979) compares western industrialized countries based on output per person-hour. In addition, the May 1990 figures of the U.S. Bureau of Labor Statistics show that the level of productivity in Canada, as measured by GDP per employee, ranked second only to the United States among a group of 14 western industrialized countries.

[12] See Economic Council of Canada; Macdonald Commission; Rao and Lemprière; Maddison (1979, 1980); and U.S. Bureau of Labor Statistics. Durand, Salem, and Hayes provide a new Canada-United States comparison of business multifactor productivity indices since 1961. This comparison incorporates the latest Statistics Canada revisions of productivity and capital stock data (see Appendix A). They conclude: "It is evident that . . . multifactor productivity gains in the two business economies have been similar in magnitude and overall trend."

Table 2-2
Labour Productivity* in Manufacturing:
Other G-7 Countries Relative to Canada, Selected Years, 1951-89

	U.S.A.	Japan	France	Germany	Italy	U.K.
	Comparison** (Canada = 100)					
1951	171.3	17.3	60.0	55.1	52.3	71.1
1955	160.6	19.7	60.1	63.1	55.5	65.5
1960	143.7	24.3	65.8	77.2	58.6	62.3
1965	138.0	28.6	69.4	80.7	66.7	57.6
1970	125.2	45.6	84.3	91.5	80.0	60.1
1975	122.8	52.6	89.4	98.8	86.3	60.5
1980	120.9	56.4	100.6	107.4	100.0	58.6
1985	123.4	73.0	99.7	106.3	108.6	64.9
1988	128.3	81.2	103.7	106.2	108.1	70.3
1989	134.0	85.4	111.0	109.5	115.2	76.7

* Output per hour.
** Based on purchasing-power parity rates, disaggregated by major industry.
Source: Estimates by P. S. Rao and T. Lemprière prepared for the Economic Council of Canada, June 1989, based on data from the U.S. Department of Labor.

These data should be interpreted with some caution. To some degree, the differences in performance are consistent with the convergence theory. In addition, both Tables 2-1 and 2-2 use purchasing-power parity calculations. Such calculations are sensitive to the choice of base and price indexes. A minor variation in indexes can result in a change in the conclusions. Moreover, an important complicating element in the analysis is the difficulty in isolating the different cyclical and structural elements at play.

There also appear to be problems of reconciliation. If it is true that Canada's productivity level in manufacturing is now lower than that of Germany, France, and Italy, and if, at the same time, Canada has remained an overall productivity leader, then it follows that Canadian productivity in non-manufacturing activities must be significantly higher and better than in those other countries. The poor quality of service-sector data, however, makes it difficult to reach any firm conclusions in this regard.[13]

[13] It has also been suggested that international differences in the statistical treatment of the contracting-out of services by manufacturing industries may have influenced these international comparisons of manufacturing productivity.

The extent to which the distinction between tradeables and nontradeables is disappearing in global markets also bears on the interpretation of Rao and Lempriere's findings. Traditionally, manufacturing has been the primary source of tradeable goods, and thus relative manufacturing productivity has been a key indicator of international competitiveness. Improvements in communications technology, however, have made many services tradeable goods. Consequently, Canada's apparent high service-sector productivity may make it equally important in shaping international competitiveness.

Another disturbing, and perhaps unique, feature of Canada's productivity and economic growth record concerns total factor productivity growth in the 1980s. As in other countries, there has been a marked slowdown in TFP growth over the last three decades, particularly between 1973 and the early 1980s. Various estimates are available for later in the 1980s, depending on the sector, the period covered, and the timeliness of the data. For the business sector, compound growth rates ranged from zero to 1.8 percent, but the period was too short to establish definitive long-run trends. The choice of beginning and end of time periods is critical when calculating these TFP growth rates. It is appropriate that they be at the same point in the business cycle. For example, the high estimate of 1.8 percent is the result of a peak-to-trough comparison. In the 1980s, however, Finance Canada estimates that TFP growth in Canada was close to zero. Statistics Canada data show a slowdown in TFP average annual growth from 2.1 percent per year from 1962 to 1969, to 0.9 percent per year from 1970 to 1979 and 0.7 percent per year from 1980 to 1989 [see Government of Canada, *Prosperity through Competitiveness* (Ottawa: 1991), p. 3; Statistics Canada, *Aggregate Productivity Measurements* (Ottawa: July 1991); and *Canadian Labour Market and Productivity Center Review* (Winter/Spring 1991).].

Using the Baumol *et al.* analysis described in Chapter 1, it is possible to identify the implications of TFP performance in terms of the mechanics of productivity growth. Recall that TFP growth can serve as a measure of that portion of labour productivity growth attributable to innovation (and other factors) and residually to that portion ascribed to investment per worker. Direct evidence is available that shows the stock of capital/labour ratios for the business sector in Canada to have been distinctly larger at the end of the 1980s than at the beginning. Thus the relatively slow growth in labour productivity in the 1980s cannot be attributed to weak investment per worker. The modest rates of growth in TFP for the business sector provide direct evidence of marked weakness in innovation and other factors in Canada during that period.

In summary, there are three features of Canadian productivity and economic growth that set them apart from the performance of other western industrialized countries in the postwar period.

1) Canada's strong labour force growth has put a premium on capital widening in order to equip new entrants to the labour force with about the same amount of capital as existing labour participants.

2) There is disturbing evidence that Canada is no longer closing the manufacturing productivity gap with the United States and that Canada's level of manufacturing productivity is now lower than that of France, Germany, and Italy. (This evidence needs to be interpreted with some caution, however, since its methodology is sensitive to assumptions and because there are problems of reconciliation with existing service and resource productivity data.)

3) Total factor productivity growth in the 1980s was lower than in the 1960s and early 1970s; in light of the labour productivity growth, this suggests a marked weakness in innovation and other factors in Canada, as opposed to investment per worker. It also suggests the possibility of misallocation of capital and of slow adaptation to the technology embodied in the newer portions of the stock of capital.

Canadian Investment and Savings Trends[14]

General Patterns

Urquhart's study of the past 110 years of economic growth in Canada serves as a useful starting point for discussion of general patterns of Canadian investment and savings. In order to adjust for the way in which Canadian aggregate investment and savings efforts vary considerably from year to year, his data on investment and savings are grouped into five-year periods. His data for the period from 1951 to 1990 are displayed in Table 2-3, and the key lessons are:

- The ratio of gross investment to GNP for each five-year period since 1951 was never less than 21.5 percent in Canada. Between 1955 and 1980, the ratio averaged a bit above 23 per cent, and under 23 per cent in the 1980s.

- The ratio of savings to GNP for each five-year period was never less than 20.16 percent. The Canadian savings effort fell a little in the 1980s, compared with the higher five-year average rates between the middle 1960s and the end of the 1970s.

[14] Various aspects of Canada's record on these matters have been examined recently by Urquhart; the Macdonald Commission; Dean *et al.*; Rao and Lemprière; Barbara Clift; the Economic Council of Canada; and Finance Canada in various budgets.

- The gross savings ratio met the vast bulk of Canadian gross investment; however, the data also show a persistent net capital inflow to Canada. Canada's postwar peak of reliance on foreign capital occurred in the latter half of the 1950s.[15]

Table 2-3
Canadian Investment and Savings Rates, 1951-90

	Ratio to GDP (in current dollars)		
	Gross fixed capital formation	Net capital inflow	Implicit savings rate
1951-55	.2158	.0142	.2016
1956-60	.2420	.0352	.2068
1961-65	.2240	.0169	.2071
1966-70	.2403	.0064	.2339
1971-75	.2328	.0089	.2239
1976-80	.2365	.0198	.2167
1981-85	.2169	.0020	.2149
1986-90	.2275*	.0175*	.2100*

* Estimate by David Slater, based on Statistics Canada's *National Accounts, Income and Expenditure* forecasts for 1990.
Source: M. C. Urquhart, *Canadian Economic Growth, 1870-1980*, Discussion Paper 734 (Kingston: Queen's University, 1988).

International comparisons of investment and savings efforts[16] for the postwar period as a whole [Dean *et al.*] show Canadian *investment* efforts as being roughly *average for the OECD*, but well below Japan, Germany, and France. The ratio of Canadian *savings* to GDP has usually been *less than the OECD average*, with Canada ranking well

[15] Note that these data do not show the two-way international flows of Canadian savings invested abroad and foreign savings invested in Canada. In this respect, recall that Canadian national accounting conventions do not count retained earnings of foreign-owned companies in Canada as flows of new, inward foreign direct investment; nor do they count comparable Canadian retained earnings abroad in outward flows. If both were explicitly included, in most years the net direct foreign investment inflow to Canada would be significantly larger than indicated by the conventional accounts. The U.S. practice is to include retained earnings.

[16] Measured as the ratio of national investment to national GDP.

below Japan, Germany, and France [see Appendix D]. Among 16 of the principal industrialized countries,[17] Canada's investment efforts ranked thirteenth highest for the period from 1960 to 1974 and eighth highest for 1974 to 1988. Canada's relatively better investment efforts in the 1980s are mainly due to the larger declines in investment effort in other countries. It is notable, however, that in this period Canadian investment efforts did exceed those of Germany and France. Furthermore, although business investment rose sharply in all G-7 countries during the 1980s, Canada's business investment growth rates and the share of business value-added that was devoted to investment were matched only by Japan [see Ford and Poret].

The International Monetary Fund reports similar results. It has shown that in the first half of the 1970s, both domestic investment and national savings, as a percentage of GNP, fell for the IMF's grouping of "all industrial countries". In the latter half of the 1970s, Canada's investment effort was well up to the average, but savings fell well below investment. In the first half of the 1980s, both Canadian investment and savings were higher than the average. In the latter part of the 1980s, investment was above average, but savings fell well below investment. The IMF attributes much of this shortfall to the size and persistence of government deficits in Canada, accompanied by the increased use of foreign savings.

Although not at the average among western industrialized countries, Canadian savings efforts can be said to have been relatively strong. The postwar experience has been marked by sustained private savings efforts contrasted with marked increases in government dissavings in the 1980s. In most years, net personal savings represented a larger proportion of net total domestic savings than net business and government savings combined. Except for the 1930s and the war years, savings efforts have generally been a little smaller than investment efforts - that is, some net use has been made of foreign savings.

Perhaps most importantly, Canadian savings rates, both personal and corporate, were persistently higher than those of its major trading partner, the United States. Over the decade of the 1980s, total Canadian private savings averaged 11.9 percent of GDP, compared with 5.5 percent in the United States. Canadian personal savings rates were more than double those in the United States (8.7 compared with 3.8 percent). Corporate savings rates in Canada were almost double those in the United States (3.3 compared with 1.7 percent).

[17] The G-7 countries, plus Austria, Denmark, Finland, the Netherlands, Norway, Sweden, New Zealand, Australia, and Switzerland.

Investment Efforts

Table 2-4
Highlights of Canada's Investment Efforts, 1960 and 1987

	1960	1987	Average annual growth rate (1960-87)
	(Billions of 1981 dollars)		(Percent)
Gross domestic product	136.6	408.1	4.3
Gross fixed capital formation	28.4	96.4	4.6
of which:			
Business GFCF	14.8	55.8	5.0
Machinery and equipment	4.8	33.9	7.5
Non-residential construction			3.1
Government GFCF			2.7
Residential construction			4.8
GFCF as a percentage of GDP	20.8	23.6	
GBFCF as a percentage of GFCF	52.1	57.9	

GDP = gross domestic product;
GFCF = gross fixed capital formation; and
GBFCF = gross business fixed capital formation.
Source: David Swimmer, *Perspectives on Canadian Investment* (Ottawa: Investment Canada, 1989).

Table 2-4 presents the highlights of Canada's real investment efforts. As developed by Swimmer (1989), the most notable features include:

- a long-run trend of increased investment effort, the pattern having been marked by a stronger effort in the 1960s and early 1970s, some letdown in the recession of the 1980s, and a more recent upturn;

- stronger growth of business investment relative to government investment; and

- an increase in the machinery and equipment share of investment efforts, generally viewed as conducive to more rapid adoption of new technology and thus productivity improvement, this being considered especially important for Canada since over the past 30 years its average machinery and equipment spending as a percentage of GDP lagged behind other industrialized countries.[18]

Table 2-5
Capital Stock* and Capital/Output Ratios, Canada, 1960, 1983, and 1987

	1960	1983	1987	Average annual growth rate (Percent)
Urquhart (for 1960 and 1983):				
Gross non-residential capital stock	$ 153,100	$ 453,937		4.8
Gross non-residential capital/output ratio	2.88	3.24		n.a.
Swimmer (for 1960 and 1987):**				
Net real capital stock	$ 97,200		$ 323,100	4.6
Business real net capital stock	$ 69,500		$ 244,500	4.8
Net non-residential capital/output ratio	1.82		1.92	n.a.

* All capital stock estimates are expressed in millions of 1971 Canadian dollars.
** The Swimmer data were based on Statistics Canada estimates published in 1988. Since then, the data have been revised for the gross and net stock of capital; the price indexes determine the constant-dollar estimates from current-dollar figures; and the base year is now 1986. These new data do not alter the qualitative conclusions of a trend of increase in capital intensity of Canadian production, but they do affect the quantitative analysis. The revisions and their implications, which are still somewhat "experimental", are discussed in Chapter 5.
Source: M. C. Urquhart, *Canadian Economic Growth, 1870-1980*, Discussion Paper 754 (Kingston: Queen's University, 1988); and David Swimmer, *Perspectives on Canadian Investment* (Ottawa: Investment Canada, 1989).

[18] Statistics Canada has recently revised its estimates of the nominal and real stock of capital, incorporating new information on lives and accelerated depreciation rates and on price trends applicable to computing and related investment. The data have also been rebased to 1986 dollars. The main effect of these changes is to reduce somewhat the estimated stock and growth of capital, particularly machinery and equipment, in comparison with previous estimates. It is important to note that the real net stock of capital estimated for the years before 1980 is not strictly comparable with that after 1980. It has not been possible to incorporate the new data into this paper, although a preliminary review indicates that the qualitative conclusions reached here would not be fundamentally altered. Tables 2-4 and 2-5 are affected, however. The effect of these revisions is discussed further in Chapter 5.

The investment effort, in turn, drives the accumulation of the stock of capital. Urquhart focuses mainly on the gross stock of capital; and Swimmer, on the net. Their summary measures are compared in Table 2-5.

Both sets of data indicate that Canada's investment effort has been sufficient to achieve a modest increase in capital/output ratios during the last quarter-century. Recalling that Canada experienced a much more rapid expansion of its labour force than most western industrialized economies and that its labour productivity also increased, it follows that capital/labour ratios have also increased.

Savings Efforts

Table 2-6 provides a breakdown of Canadian savings trends from 1960 to 1987, constructed from statistics in OECD (1990), following the pattern used by Dean *et al.* All figures are percentages of GDP for the period specified. The latest Canadian data tell the same story, but with slightly different numerical estimates [Statistics Canada, July 1991].

The data in Table 2-6 show a similar pattern to that of Urquhart, with medium to high savings efforts marked by some decline in the 1980s. They also add some important details:

- a strongly sustained gross private savings effort contrasted with marked increases in government dissavings (or net government lending) in the 1980s; and
- a large and relatively stable gross savings effort with capital cost allowances contributing to more than half of those savings.

Net business savings averaged over 4 percent of GDP, again with rather wide cyclical variations. An examination of Canada's national accounts indicates that corporate profits before tax averaged about 11 percent of GDP in the postwar period, with much cyclical variation. On average, after-tax profits of over 6 percent of GDP were divided as follows: slightly less than half to dividends and the rest to retained earnings.

Table 2-6
Details of Canadian Savings, Selected Periods, 1960-87

Savings measures*	1960-67	1968-73	1974-79	1980-87	Summary 1960-87
Gross savings	21.3	22.2	22.6	20.7	22.3
less CCA	11.8	11.1	11.0	12.3	12.3
Net savings	9.5	11.1	11.6	8.4	10.0
Gross Savings	21.3	22.2	22.6	20.7	22.3
less net gov't lending‡	-0.8	0.7	-1.7	-5.1	-1.9
Gross private savings	22.1	21.5	24.3	25.8	24.2
Gross savings	21.3	22.2	22.6	20.7	22.3
plus foreign savings†	1.7	0.2	2.2	0.9	1.2
less residual**	-0.4	-0.3	-1.3	-0.3	-1.2
Gross fixed capital formation	22.6	22.1	23.5	21.3	22.3
less CCA	11.8	11.1	11.0	12.3	12.3
Net fixed capital formation	10.8	11.0	12.5	9.0	10.0
Net household savings as a percentage of disposable household income	5.9	7.5	12.4	14.0	9.9

* All values are shown as a percentage of GDP, with the exception of net household savings.
** The residual includes foreign savings not used in gross fixed capital formation and all Canadian direct investment abroad.
CCA = capital cost allowance.
† Positive sign implies net capital inflow.
‡ Negative sign implies net government deficit, *National Accounts* measurement.
Source: Organisation for Economic Co-operation and Development, "Historical Statistics: 1960-88", *OECD Economic Outlook* (Paris: OECD, 1990).

In most years, personal savings make a much larger contribution to net domestic savings in Canada than business and government savings combined. The components of personal savings have been analyzed by Clift for the period 1961 to 1987 and reveal the following trends:

- The ratio of personal savings to personal disposable income trended strongly upwards from 1961 to 1982 and declined thereafter, though not down to the levels of the 1960s. Between 1974 and 1987, the ratio was high, averaging above 12 percent, and it was still close to 10 percent in 1987. In 1982, the ratio peaked at 17.8 percent, following a high of 15 percent in 1981.[19]

- The ratio of a composite of savings - through "life insurance", "trusteed pension plans", and "registered retirement savings plans" - to personal disposable income grew steadily. Except for the high personal savings efforts from 1981 to 1982, these three forms of savings accounted for nearly 60 percent of personal savings from the mid-1970s through 1987.

- The proportion of personal disposable income in the form of savings of "private non-profit institutions" showed little growth or variation.

- The ratio of "savings available for other uses" - including household mortgage repayments and instalment and credit card repayments - grew but varied widely.

- The high ratios of savings in the highly liquid forms of "currency and deposits" between 1973 and 1982 were preceded and followed by lower ratios. A very large fraction of these savings flowed through financial intermediaries, rather than directly, to ultimate users.

- Net mortgage liabilities increased substantially between 1973 and 1978; this was followed by a marked reduction in the growth of mortgage debt between 1980 and 1985, and a resumption of growth since then. In the period of peak interest rates in the early 1980s, the net increase in mortgage liabilities of the personal sector came close to zero.

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[19] Consistent with Clift's analysis, the record shows that personal savings rates were well maintained in Canada throughout the rest of the 1980s. As percentages of personal disposable income, the rates were: 1987, 9.2 percent; 1988, 9.9 percent; 1989, 10.8 percent; 1990, 10.7 percent. More recently, Bosworth, Burtless, and Sabelhaus have published an analysis of U.S. personal saving, with a comparable analysis for Canada and Japan. They point to, but do not fully analyze, the blip in Canadian savings rates in the early 1980s, coincident with the exceptionally high interest rates and related adjustments in mortgage financing, increased holdings of liquid assets, and accelerated paybacks of outstanding consumer debt. See The Brookings Institution, *Brookings Papers on Economic Activity*, vol. 1 (Washington: Brookings Institution, 1991).

Important messages regarding both past trends and future prospects arise from this personal savings record. In Canada, there was, and will be, a solid core of steady commitment to personal savings through the accumulation of assets in life insurance contracts, funded trusteed pension plans, and registered retirement savings plans. Moreover, Canadian habits in the use of intermediaries for savings appear to be deeply entrenched. The role of these intermediaries in influencing the disposition of savings is, and has been, significant in Canada. Such institutional arrangements are a major factor. Finally, the largest single factor in the extremely high personal savings rates of the early 1980s was the extraordinary paydown in mortgage liabilities associated with peak interest rates. This suggests that such high personal savings rates are not likely sustainable in the future.

Conclusions

Among western industrialized countries during the postwar years, Canada achieved about an average investment effort and a less-than-average savings effort. The ratio of gross investment to GNP for each five-year period since 1950 was never less than 21.5 percent. Real capital/output ratios have been maintained, and even increased marginally, since the end of the war. There is a long-run trend of increased investment effort, characterized by relatively strong business investment and a notable increase in the share of machinery and equipment, although Canadian aggregate investment and savings efforts, as well as their individual components, vary considerably from year to year.

Canada's private savings effort has generally been less than average for the western industrialized economies, yet higher than that of its major trading partner, the United States. These savings are, for the most part, deployed through financial intermediaries and capital markets. During much of the postwar period, Canada continued to be a modest net capital importer. The shortfall of Canada's savings effort below the national investment effort in the 1980s was significant and worrisome. The main cause was the shift of governments at all levels from net savers in national accounts measures in the 1960s and early 1970s to net dissavers in the 1980s. In most years, net personal savings is a larger proportion of net total domestic savings than business and government savings combined. In this respect, there is a solid core of Canadian personal savings committed by contract to life insurance, trusteed pension plans, and registered retirement savings plans.

CHAPTER 3
The Adequacy of Past Investment and Savings Efforts

THE ADEQUACY OF PAST INVESTMENT AND SAVINGS EFFORTS

This chapter considers the adequacy of past Canadian investment and savings efforts. Adequacy is considered from a number of different vantage points, including investment and the capital stock, savings and the role of foreign capital, the mix of capital formation, the pace of innovation, and - perhaps the most important - productivity and its links to investment and other factors.

Investment and the Capital Stock

Was Canadian investment effort sufficient to maintain, or to increase, the stock of capital per worker during a period of rapid growth in the employed labour force? At the most elementary level, the answer is yes. Since 1960, the stocks per worker have increased substantially, as Table 3-1 illustrates. This is just saying, however, that investment was sufficient to equip the expanding labour force given the growth in output.

The significance of this observation is not clear. A nation with an abundant supply of plant and equipment can be expected to be in a position to produce a relatively large output. At the same time, an economy with a larger output is in a better position to build plant and equipment. Which of these two relationships plays the preponderant role in the observed close relationship between investment and output has been a matter for inconclusive debate among analysts. Baumol *et al.* are likely right to conjecture that "both of the two-way relationships are of some importance in reality" (p. 167).

It could also be simplistically argued that since Canada's investment effort was about average among the OECD countries during the postwar period, these efforts have been sufficient. In reality, however, being at the average says little about adequacy. In fact, it is reasonable to expect that the adequacy of investment and savings would be different among countries because of unique characteristics. In the case of Canada, it can be argued that "adequate" capital/output ratios should be relatively high, because of the country's size, its climate, and its specialization in capital-intensive activities in energy, resource extraction, and manufacturing. From this perspective, the fact that Canada was at the OECD average might suggest that not enough investment took place.

Table 3-1
Growth rates of Labour, Output and Capital, Canada, 1960-87

	Growth rate
Population	1.33
Labour force (1966-89)	2.60
Employment (1966-89)	2.49
Real GDP	4.86
Gross stock of capital, excluding residential housing (Urquhart, 1960-83)	4.83
Net stock of capital, excluding residential housing (Swimmer, 1960-87)	4.6
Net stock of capital, excluding residential housing, in business sector (Swimmer, 1960-87)	4.8
Real net stock of capital per employee, all industries (Swimmer, 1960-87)	1.5

Note: The capital/labour ratio for the business sector in Canada from 1961 through 1988 was charted by Durand *et al.* The ratio was approximately 50 percent larger in 1988 than in 1961. More recently, Statistics Canada (1991) also charted the ratio based on revised data, with qualitatively similar results. Note that the labour force and employment data were revised back to 1966 by Statistics Canada. Earlier figures are on a slightly different basis. The 1989 revisions of the stock of capital, price indexes, and rebasing of the national accounts reduced the estimated levels and growth rates of the stock of capital. The revised growth rates of the latter, however, continue to be more rapid than those of employment in total, or in the business sector.
Source: M. C. Urquhart, *Canadian Economic Growth, 1870-1980*, Discussion Paper 734 (Kingston: Queen's University, 1988); and David Swimmer, *Perspectives on Canadian Investment* (Ottawa: Investment Canada, 1989).

Savings and the Role of Foreign Capital

It is one thing to ask about the adequacy of Canada's investment effort and the stock of capital; it is quite another to ask about the adequacy of its savings effort. That is because investment in Canada does not have to be based on Canadian savings, and investment by Canadians need not be undertaken in Canada only.

Canadian dependence on foreign capital reached its peak shortly before the First World War, in order to meet the demands arising from settlement of the West and railway expansion. Then it fell from the 1920s until 1950, with net capital outflows in the last fifteen years of that period, first because of the Depression and then because of war financing. During that time the debt-service burden, in comparison with Canadian

income and exports, was severe only during the Depression. Dependence on foreign capital peaked in the late 1950s and diminished thereafter. From the early 1960s, net external debt averaged less than 30 percent of GNP, except for the latter half of the 1980s.

In the last half of the 1980s, the gap between Canadian savings and investment became unusually large, more because national savings ratios were unusually small than because Canadian investment efforts were unusually large. Net external debt mounted faster than Canadian income or exports. With interest rates on the rise, the interest paid on the external debt increased even more rapidly than the stock of external debt. The increased debt was not matched by an increase in investment, which could have pushed capital/output ratios for Canada to significantly higher levels. The increased capital inflow has essentially been consumed either directly by consumers or, to a large extent, indirectly as a by-product of government deficits. During this latter period, Canadian national savings efforts have been inadequate. Through various adjustments in capital markets, the gap has been filled by increases in Canada's net international indebtedness - some private and some public.

Dean *et al.* attempt to address the adequacy of personal or household savings by linking the relative size of household savings efforts to differing socio-economic influences in the G-7 countries. The influences considered are: old age dependency; young age dependency; the participation rates of the population over age 65; population growth, and the participation rates of women. On the basis of the ranking of each of these influences, viewed in terms of whether they encourage or discourage savings, the authors suggest that Italy would be expected to make the largest household savings effort. Italian savings are consistent with that expectation. For Canada, the ranking of the influencing factors indicates it would be expected to rank in the middle, in terms of its household savings effort. It turns out that Canada's effort ranks as expected. This does not demonstrate adequacy. The combination of this Canadian ranking and the data from Clift's analysis does, however, reinforce the view that a persistent and relatively high propensity to save exists among Canadian households.

The Pace of Innovation

There have been continuing concerns in Canada about relatively low levels of R&D spending and the inability to adopt rapidly the most efficient and innovative production and distribution practices from abroad.[20] Closely related have been weaknesses in

[20] Don McFetridge of Carleton University indicated in a recent conversation that a Canada-U.S. survey of the adoption of five new off-the-shelf technological advances showed that Canadian rates of adoption were slightly faster than those in the United States; however, the results are preliminary and, in any case, concern a fairly narrow range of innovations. See also Macdonald Commission; Science Council; and Economic Council (1988, 1989).

developing and expanding international markets. All these problems may have reflected in part a failure to invest sufficiently in innovation processes. The analysis in Chapter 2 on TFP growth suggested that innovation was a significant weakness for Canada, particularly in the 1980s. Investment in machinery and equipment clearly bears upon these concerns.

It would not be useful in this context to review the substantial literature on the innovation issue. Suffice it to say that a number of factors may be contributing to inertia relating to innovation processes in Canada:

- sheltered Canadian markets (which are now becoming less sheltered with the implementation of the Canada-U.S. Free Trade Agreement);
- the comparative shortage of engineers and other applied scientists, and their low standing on the totem pole of management and entrepreneurship;
- the inadequate equity financing of small and medium-sized innovative business activity in Canada, especially in the development phase of the product cycle [see Sharwood; and Economic Council of Canada (1988, 1989)]; and
- the alleged risk aversion of Canadian investors and their financial intermediaries.[21]

The Canadian experience with spending on machinery and equipment reveals the special problems for the country in the investment/productivity linkages relating to innovation. On the one hand, the evidence shows that there was a relatively strong increase in machinery and equipment spending in the 1980s, although over the past 30 years, Canada's average machinery and equipment spending as a percentage of GDP lagged behind other industrialized countries. On the other hand, however, it was concluded, based on the mechanics of productivity growth explained in Chapter 2, that rather low total factor productivity growth, combined with modestly rising labour productivity growth in the same period, suggested a marked weakness in "innovation and other factors", rather than in "investment per worker". This result is surprising and contrary to the general view that machinery and equipment spending is conducive to

[21] This risk aversion is somewhat difficult to square with the speculative image of the Vancouver Stock Exchange and the bad loan performance of certain Canadian financial institutions. Our record on the latter is, of course, better than that of the United States (take, for instance, the savings and loans debacle).

more rapid adoption of technology. The result is also contrary to the recent economic growth theories, which contend that the accumulation of machinery and equipment is the most important determinant of productivity growth.[22]

Charts 3-1 and 3-2 provide further evidence of this puzzle. They show a positive correlation between labour productivity and investment in machinery and equipment in the long run. There was a strong and significant correlation, except in the years from 1979 to 1983, between labour productivity and investment in machinery and equipment per employee (Table 3-2).

Table 3-2
Relationship between Labour Productivity and Investment in Machinery and Equipment, per Employee, 1968-89

Dependent variable is GDP per employee.
Sample range: 1968 to 1989 (with the recession and oil shock years, 1979 to 1983 removed).

VARIABLE	COEFFICIENT	STD. ERROR	T-STATISTIC	2-TAIL SIG.
Constant	40422.636	7496.2548	5.3923775	0.000
MEEMPL*	1.8785257	0.9787233	1.9193634	0.077
AR(1)**	0.9078267	0.0768349	11.815285	0.000

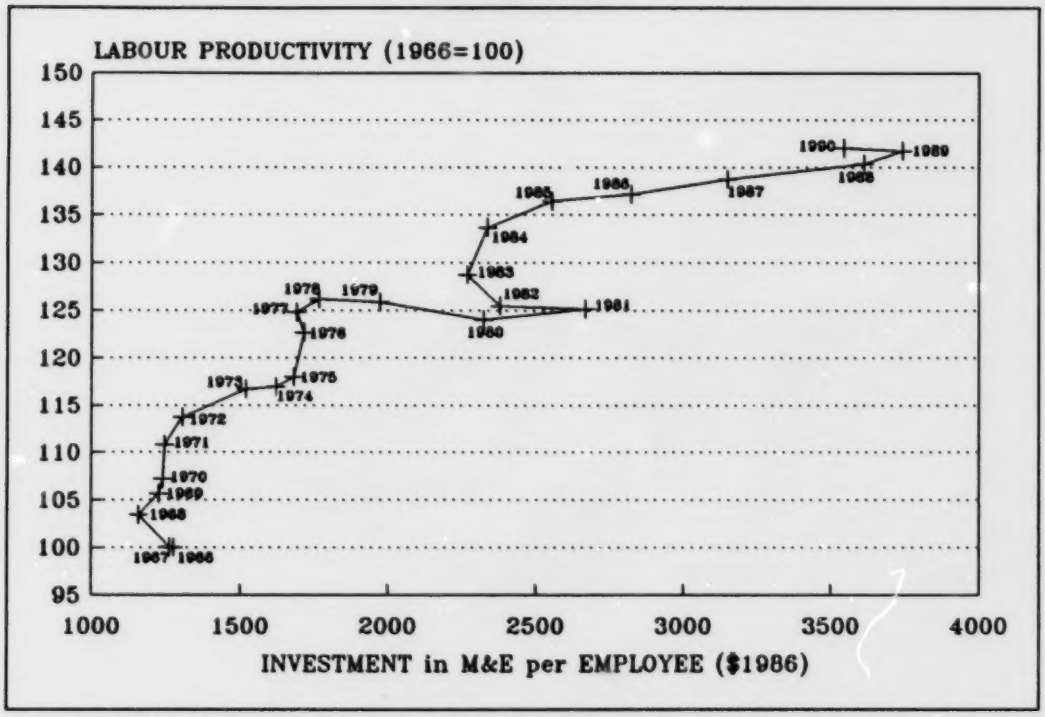
R-squared	0.984774	Mean of dependent variable	39775.49
Adjusted R-squared	0.982431	S.D. of dependent variable	3925.563
S.E. of regression	520.3244	Sum of squared residual	3519587.
Durbin-Watson statistic	1.614121	F-statistic	420.3908

* Machinery and equipment per employee.
** First-order correction for autocorrelation, using the Cochrane-Orcutt method.

From 1966 to 1973, both labour and total factor productivity were responsive to changes in investment in machinery and equipment per employee. The 1973 oil shock affected labour productivity for about two years, but TFP trends were significantly affected until after the recession in 1981 and 1982. After 1978 the upward trend in labour productivity was also set back. This watershed in the labour productivity trend occurred at a time when three adverse conditions coincided. First, there was a second round of oil shocks. Second, there was the recession in 1981 and 1982. Third, the National Energy Policy initiated during that period inhibited, among other things, investment in the oil and gas industries. From 1978 to 1983 labour productivity became highly inelastic, but for TFP the period of inelasticity began in 1973 and lasted ten years. After 1983, there was a marked difference in the upward trends between the two productivity measures.

[22] Evidence consistent with this view is presented in a recent study of productivity growth in a cross-section of 25 countries by DeLong and Summers. These authors contend that the accumulation of machinery is the most important determinant of productivity growth. From this perspective, investment effort becomes even more important than in the traditional neoclassical view.

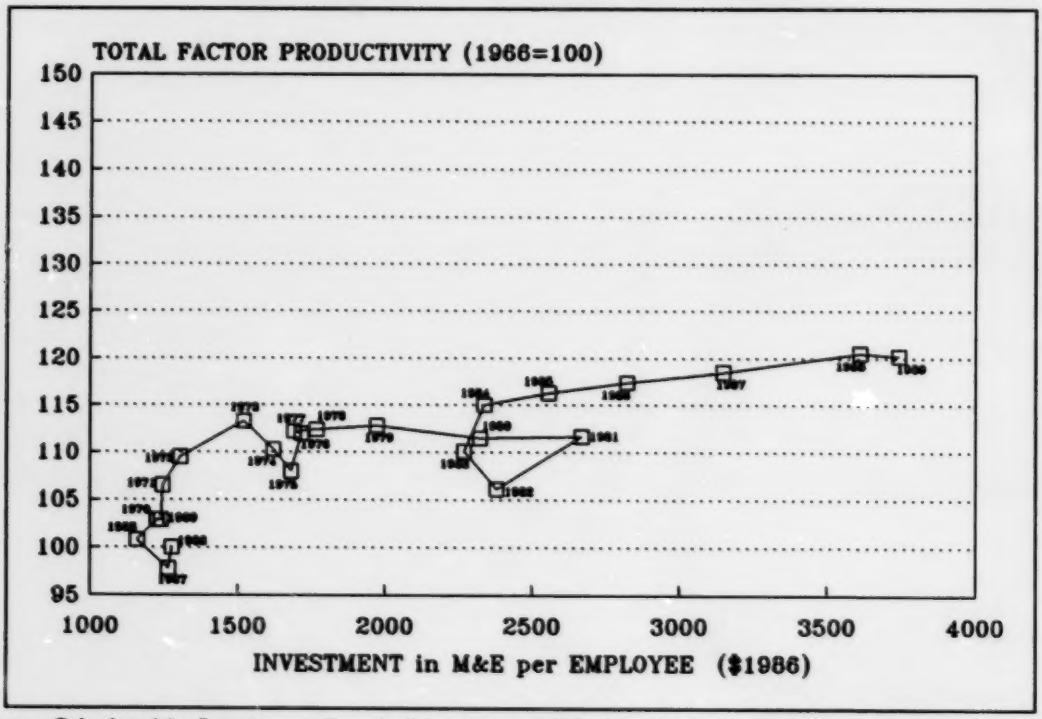
Chart 3-1
Investment in Machinery and Equipment per Employee and Labour Productivity, Canada, 1966-90



Source: Calculated by Investment Canada from data published by Statistics Canada in *The Labour Force*, and *National Income and Expenditure Accounts*, Ottawa, various issues.

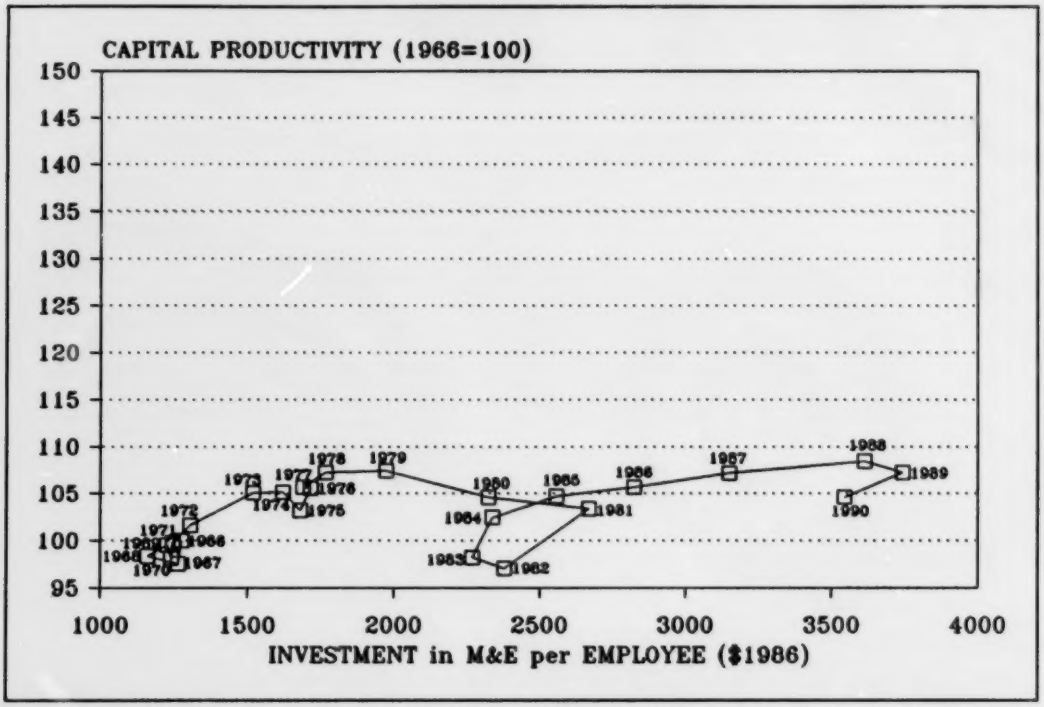
Chart 3-1 shows that labour productivity recovered by 1984 and continued on the old trend, but at a slower rate of growth, as the economy moved out of recession and expanded. In contrast, total factor productivy, as demonstrated in Chart 3-2, rose only slowly after 1983. Both of these trends took place in an atmosphere of significantly higher levels of real investment in machinery and equipment per employee, compared with the 1970s. But capital productivity — defined as output per dollar invested — appears to have little relationship to investment in machinery and equipment. This can be seen in Chart 3-3. These results confirm the puzzle, emphasizing the fact that, for Canada, there are many unanswered questions about the type and quality of investment required.

Chart 3-2
Investment in Machinery and Equipment per Employee and Total Factor Productivity, Canada, 1966-89



Source: Calculated by Investment Canada from data published by Statistics Canada in *Aggregate Productivity Measures*, July 1991, page 119; and *System of National Accounts*, various issues.

Chart 3-3
Investment in Machinery and Equipment per Employee and Capital Productivity, Canada, 1966-90



Source: Calculated by Investment Canada from data published by Statistics Canada in *Fixed Capital Flows and Stocks* and *System of National Accounts*, various issues.

The Mix of Capital Formation

These puzzles relating to the type and quality of investment are no doubt related to the mix of capital formation. The following views on the mix of capital formation have considerable support in Canada:

- As a broad generalization, Canadians have put too much capital into residential housing, though less than U.S. residents who have stronger tax and financing incentives to do so. While there are housing inadequacies, they are more than matched by the "over-housed" position of many home owners.

- The government's share of capital formation has been falling and the business share increasing. There are positive and negative sides to this trend. The positive side is that business may have experienced a stronger incentive to be

more efficient in the use of capital, employing more energy-conserving machinery and equipment and investing in more technologically oriented capital. The negative side is that the responsibility of government to maintain and expand public infrastructure in Canada may not have been fulfilled. In fact, there is widespread concern in Canada today about the deterioration of road systems, congestion at airports, the breakdowns and inadequacies of sewage systems, and the neglect of educational facilities.

- The proportion of total business non-residential capital formation used for machinery and equipment has risen as the proportion used for construction has fallen (see Table 2-4 in Chapter 2). Investment in machinery and equipment is an important vehicle for the introduction of new technology. Furthermore, some recent theories of economic growth emphasize positive spillovers associated with the heavy research and development expenditures required in the capital goods sector.

On the question of infrastructure, the facts support the case that Canadian efforts have dropped significantly. From the mid-1970s to the end of the 1980s, expenditures on infrastructure relative to GDP, which were as high as 2.8 percent in 1977, slipped to as low as 1.6 percent in 1987, before rising to 1.8 percent of GDP in 1989. Among the G-7 countries, only the United States and the United Kingdom ranked lower than Canada. Moreover, this decline in infrastructure investment effort is significant, since infrastructure renewal costs tend to increase geometrically over time. For example, the cost of road resurfacing, often considered to be the most pressing infrastructure problem, increases from $.50 per square foot if maintained every 15 years, to $1.00 per square foot if repaired every 20 years, and to $1.50 per square foot if maintained every 25 years [see Swimmer, *Infrastructure*].

Moreover, it is conceivable that expenditures on machinery and equipment can hold fast, or even reduce, productivity if the proper technology is not embodied in the new capital. Consequently, the type of machinery and equipment purchased in the 1980s may have contributed to Canada's productivity problems instead of helping, as traditionally expected. Some possible explanations include the following:

- Canada's relative use of energy-intensive machinery and equipment has not decreased as much as in other countries, whose post-1970s slowdown in productivity was less pronounced. In this respect, Canada has not adjusted to the energy shocks of the late 1970s and early 1980s as fast as other industrialized economies.

- The number of high-technology production facilities in Canada is proportionately lower than in Japan, Germany, and the United States.

- Canada has had a history of geographic mismatches in labour skills, with surpluses in some areas and shortages of the same type in others. As a result, new machinery and equipment may not be operated efficiently, especially if, as many allege, a lack of general entrepreneurial expertise and vision is deficient among Canadian businessmen.

Swimmer (1989) provides some evidence in support of the view that machinery and equipment spending can hold up, or even reduce, productivity. As the capital stock ages, it loses both efficiency and productivity.[23] Machinery and equipment that is closer to the end of its prescribed useful life requires higher infusions of less-productive repair capital to maintain its output at a constant, or even declining, level of efficiency. This lowers the rate of marginal returns, competitiveness, and profitability. In contrast, new machinery and equipment, which normally incorporates more-advanced technology, is generally more efficient and productive, and it costs less in upkeep. From 1971 to 1979, the average age of machinery and equipment declined from 9.2 to 8.8 years. Over the following two years it remained stable; but from 1982 to 1987, it *increased* to 9.6 years. Consequently, over the 17-year period, the age of machinery and equipment averaged about 9 years. Since the 1982-to-1983 recession, however, its age has been rising to the extent that in 1987 it was almost one year older than at the start of the recession. New data for recent years show the age of the stock of machinery and equipment to be decreasing.

Productivity Growth: Links to Investment and Other Factors

As discussed in Chapter 1, there is no question that in the long run, investment/productivity links are demonstrable and essential for Canada and other industrialized countries. The role of investment in explaining the productivity slowdown of the 1970s and 1980s is complex, however, and the empirically derived linkages are not as strong or direct as expected by economic theory. This is true for all industrialized countries, but especially for Canada.

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[23] The observation about aging is based on Statistics Canada estimates of the stock of capital in Canada made prior to 1989. They do not take into account the revisions made in investment and the stock of capital since 1989. Nor do they take account of the adjustment that may arise out of Jaffey's critique, discussed in Appendix A. The revisions that have been made show a marked reduction in the aging of the machinery and equipment stock of capital between 1986 and 1990. Beyond this, reconstructing capital stock measurements along the lines of Jaffey's article would reduce the assumed lives of vintages of capital and accelerate discards. Gross and net stocks of capital would be reduced; gross factor productivity would be increased; and the partitioning of that productivity among factors would be altered. Moreover, if Jaffey is right, it could be the case that statistical measurement problems are at the heart of the puzzle about the machinery and equipment investment/productivity links.

To support the view that there are complex relationships and other factors involved, it is useful to compare trends in Australia and Canada, as shown in Tables 3-3, 3-4, and 3-5. Both are mixed economies of similar industrial/commercial age, and both had high rates of immigration and population growth during the postwar years. In the 1970s and 1980s, Australia's capital accumulation consistently exceeded that of Canada; yet its productivity growth and overall economic growth were persistently much lower. This rather crude comparison underlines that other economic factors must be at play along with the physical investment/productivity linkages.

Table 3-3
Growth of Gross Real Business Capital Stock per Person Employed, Selected Industrialized Countries, 1965-87

	Average annual growth rate of capital stock per person employed		
	1965-73	1973-80	1980-87
Canada	2.15	2.22	2.33
France	4.78	3.79	2.75
Germany	5.28	3.82	2.29
Japan	11.51	6.08	6.73
U.K.	3.86	2.63	2.06
U.S.A.	1.80	1.45	1.34
Australia*	2.75	2.58	1.75
Average**	4.89	3.36	2.92

* 1966-73.
** Australia is not included in the average.
Source: Organisation for Economic Co-operation and Development, *Flows and Stocks of Fixed Capital, 1962-87*; and OECD, *Labour Force Statistics, 1968-88.*

For Canada alone, the evidence shows that while its investment efforts between the 1960s and the 1980s fell, they did not fall as much as those in many other countries. Canada's investment efforts moved from average to above-average among OECD

countries. Yet Canada's productivity performance was relatively worse than that of other industrialized countries, particularly in the 1980s. So although weak Canadian investment and savings efforts were factors contributing to Canada's unsatisfactory productivity performance, other economic factors appear to have played a significant role as well.

Table 3-3 shows the average annual growth of capital/labour ratios from 1965 to 1987 for six industrialized countries and for Australia, which is included for comparative purposes but is not included in the averages (as measured by OECD data on the business capital stock per person employed). Contrary to Maddison[24] but consistent with Boltho, this table *supports the view that there was a decline in investment ratios among industrialized countries associated with the productivity and economic slowdown of the 1970s and 1980s*. This post-1973 decline in the capital stock per person employed is found for all countries, *except Canada and Japan*, and for the latter in the 1980-87 period only. These declines in capital/labour ratios occurred at the same time as decreases in labour productivity in manufacturing for these six countries - 5.73 percent from 1965 to 1973, 3.33 percent from 1973 to 1980, and 3.28 percent from 1980 to 1987.

To understand the factors underlying Canada's unique experience, Tables 3-4 and 3-5 set out the components of the capital/labour ratios. What the data show in Table 3-5 is that, as discussed earlier, Canada, along with the United States, experienced a very strong rate of labour growth relative to other industrialized countries. In contrast, the growth of real business capital stock in Canada in Table 3-4 was second only to Japan among those countries since 1973. It remained strong and constant between 1965 and 1980, but then the growth rate dropped markedly in the 1980s.

The tables demonstrate that a large portion of Canada's investment per worker relative to that in other industrialized countries has been attributed to capital widening and to meeting the demands of an expanding labour force. Moreover, they indicate that the growth of investment per worker was relatively high.

In considering the weakness of the relationship between Canada's investment ratios and productivity growth, two offsetting factors are worthy of note. First, while Canada's growth rate increased marginally in the two later periods as productivity growth fell, the growth rate of business capital per employed person persistently ranked low among the six industrialized countries - second lowest in the first two periods and third lowest from 1980 to 1987. Second, the growth rate of the business capital stock alone dropped markedly in the 1980s from over 5 to less than 4 percent.

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[24] See Table 1-3 in Chapter 1. Table 3-3 uses the measure "capital stock per person employed"; Maddison's data, "capital stock per person-hour".

Table 3-4
Growth of Gross Fixed Real Business Capital Stock, Selected Industrialized Countries and Selected Periods, 1965-87

	Average annual growth rate of gross fixed real business capital stock		
	1965-73	1973-80	1980-87
Canada	5.15	5.19	3.83
France	5.64	4.30	2.53
Germany	5.27	3.47	2.76
Japan	13.00	6.86	7.73
U.K.	3.82	2.80	1.91
U.S.A.	4.11	3.72	3.16
Australia*	5.44	3.76	3.64
Average**	6.17	4.39	3.65

* 1966-73.
** Australia is not included in the average.
Source: Organisation for Economic Cooperation and Development, *Flows and Stocks of Fixed Capital, 1962-87.*

These data clearly reinforce the conclusion that in Canada's case, while investment per worker is important, it is not sufficient to explain the productivity and economic slowdown in the 1970s and 1980s. The full story involves innovation and other economic factors, and these factors bear directly on the intangible elements of total factor productivity growth discussed earlier. Nevertheless, some of these factors operated interdependently with Canadian investment and savings; others, more uniquely. What were these other factors? They likely include the following:

- The relatively large pool of underexploited technology that was available during the first three decades after the Second World War offered opportunities for reducing gaps between Canadian and U.S. productivity, but that pool gradually diminished and was exhausted in the late 1970s and 1980s.

Table 3-5
Employment Growth, Selected Industrialized Countries, and Selected Periods, 1965-87

	Average annual growth rate of total civilians employed		
	1965-73	1973-80	1980-87
Canada	2.94	2.91	1.47
France	0.82	0.32	-0.21
Germany	0.00	-0.34	0.45
Japan	1.33	0.74	0.94
U.K.	-0.03	0.17	-0.14
U.S.A.	2.27	2.24	1.79
Australia	2.62*	1.14	1.86
Average**	1.22	1.01	0.72

* 1966-1973.
** Australia is not included in the average.
Source: Organisation for Economic Cooperation and Development, *Labour Force Statistics, 1968-88.*

- Trade barriers were reduced up to the mid-1970s, and non-tariff barriers increased thereafter.

- Modest increases in real rates of pay, particularly in the 1950s and 1960s, brought about substantial increases in the labour force both from immigration and from transfers out of agriculture and other primary industries. These opportunities dissipated after the mid-1970s.

- Canada's terms of international trade improved into the mid-1970s and deteriorated thereafter.

- The welfare state developed rather slowly in Canada during the two decades following the end of the war, but much more rapidly in the late 1960s and 1970s.

The maturing of social welfare programs and their increased costs occurred after the mid-1970s.

- Canada was a leader in the acceleration of inflation among the western industrialized economies in the 1970s. Inflation became more entrenched in Canada than in the United States, Japan, and Germany. Canada suffered more from stagflation than many other industrial countries, but notably worse than its major trading partner, the United States.

- Canada, along with other industrialized economies, experienced increased uncertainties relating to the instability of the international monetary system in the 1970s and 1980s.

One lesson is clear; namely, conditions of demand and competitiveness have had major effects upon realized productivity. The wartime years demonstrate that fact well. The increase in Canadian productivity during the Second World War was phenomenal. It followed a decade of low investment in Canada and was accompanied by limited wartime capital accumulation; however, it was characterized by high demand, full employment, and significant specialization in production.

While these factors and innovation explain more of Canada's productivity and economic slowdown in the 1970s and 1980s, it does not follow that investment per worker is unimportant for productivity growth. The fact is that a positive correlation existed in Canada between investment effort and productivity and economic growth during the postwar period. Moreover, in all of the theories of economic growth reviewed in Appendix B, it is invariably argued that *investment is necessary to improve both potential and actual productivity growth*. Analysts only dispute the degree and the various mechanisms.

It is possible to imagine a situation where there is no positive correlation between investment and productivity growth but yet they are related; however, that is an extreme case. It could occur if technological advances were highly capital-saving under neoclassical assumptions where production functions include both embodied and disembodied technological improvements.[25] For example, it could be argued that the widespread use and adoption of computers into the workplace has had that result. Astonishing technological improvements in computers, accomplished in very short time

[25] We are indebted to Mike McCracken of Informetrica for pointing out, and reviewing, these relationships.

frames, accompanied by significantly declining prices and increasing applications to production processes, may have actually increased and improved the quality of output while greatly decreasing capital costs.[26]

Thus *investment is a necessary but not sufficient condition for productivity and economic growth.* In its simplest terms, as long as Canada's population is growing, more physical capital is necessary just to equip its workers in the labour force. In addition, capital deepening is essential. Moreover, some recent economic theories suggest that there is a substantial gap between the private and social returns to investment and savings.

Related Issues

It is useful to review in some detail a number of economic factors that relate to past investment and productivity growth. While they do not always conclusively explain Canada's postwar experience, these issues deserve policy attention. The issues were central to the way in which investment and the capital stock interact with the other major factors underlying the poor productivity and economic growth record of recent years.

Deficiencies in Labour Force Quality and Skills

While the quality and skills of Canada's labour force may be below desired standards, the question is whether they deteriorated in the mid-1970s and 1980s. Our relative standing among other industrialized countries is also an issue [see Maddock and McLean]. Moreover, the proportion of Canada's GDP devoted to education ranked high among OECD countries, and educational programs have been easily accessible in Canada compared with other countries. Whether future improvements in the quality and skills of the labour force would make worthwhile contributions to growth in Canadian productivity is another matter.

Deficiencies in Research and Development Activity

The scale and structure of R&D activity in Canada may well be deficient, but the proportion in relation to the economy appears to have been much the same as in the 1950s and 1960s. In terms of the mix between research and development, the development component seems to have increased - a shift that analysts suggest favours an acceleration of productivity growth. It is essential to note, too, that Canada's experience in the 1970s and 1980s with R&D incentives (as well as general investment

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[26] Ford and Poret argue that conventional national accounting methods understate the increase in the volume of computer investment in the 1980s. Both Canada and the United States have made some adjustments to their national accounts to reflect investment and the pricing of computers and related materials; however, the appropriate adjustments remain unsettled issues.

incentives), through tax concessions, subsidies, and the like, produced limited results and yielded little effective real capital - this, in spite of the fact that Canada's R&D incentive program is among the most generous in western industrialized economies.[27]

Unproductive Elements of the Capital Stock

Some elements of Canada's stock of capital have turned out to be unproductive or poorly productive. Critics point to excess supply and low profitability of coal mines, high-cost tar-sands extraction projects, pulp and paper and steel mills, unnecessary duplication of railroad lines, government-sponsored "Taj Mahals" in every province, and so on. Subsidization of inefficient regional activities exist. Every country, however, has had poor investments - at least with the benefit of hindsight. The question is whether Canada has trended towards a higher proportion of poor investments and whether that trend has been stronger than comparable ones for other western industrialized economies.

There appears to have been a lag in the full realization of the productivity of some new investment in Canada during the 1980s. With new technologies, such as computing and information systems, working through the learning curves takes considerable time. Thus it may not be that the additions to the capital stock will be unproductive; instead, they may be realized only over extended periods of time. For international comparisons, an interesting issue is the timing of the widespread adoption and use of new technologies; that, however, goes beyond the scope of this paper.

Investment Errors by Financial Institutions

Canada's banks experienced huge losses on sovereign loans to Third World countries, and some financial institutions experienced heavy losses in funding energy projects, corporate restructuring, and real estate projects. These losses are not just paper transactions. They translate sooner or later into real losses of product for the economy. The questions are whether there has been a trend of increase in these losses in Canada and, if so, whether it was strong enough to add significantly to the slowing of productivity growth. Canada's international banks shared the loss problems of Third World debt with

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[27] Special tax incentives are available to encourage the undertaking of scientific research and experimental development in Canada. All current expenditures (such as direct salaries and other operating costs) and certain capital expenditures on eligible R&D activities can be written off in the year incurred. While the cost of buildings used for R&D must be claimed at the standard declining-balance CCA rate of 5 percent, the cost of specialized structures and equipment used for R&D may be written off in the year incurred. In addition, there is an investment tax credit (ITC) of 20 percent for eligible R&D expenditures (although the ITC is 30 percent for R&D carried out in the Atlantic provinces and the Gaspé). The ITC for R&D applies to all current expenses (such as salaries), as well as capital expenditures on equipment and specialized structures used in qualified R&D activities. The annual amount that a corporation may claim for an ITC related to R&D expenditures is 75 percent of the federal corporate tax otherwise payable, and an unused R&D investment tax credit can be carried back 3 years and forward 10 years.

the leading U.S., British, and Japanese banks. The losses of financial institutions in real estate financing in Canada look small, compared with the savings and loan situation and the other banking problems in the United States. Leveraged buy-outs and the use of junk bonds appear to have been proportionately much less prevalent in Canada than in the United States.

Conclusions

At the most elementary level, there has been sufficient investment effort in Canada over the last three decades. Capital stocks per worker increased substantially, and Canadian investment effort was about average among the other OECD countries. Concerning savings, the performance was relatively satisfactory throughout the postwar period, although it deteriorated in the 1980s.

A more sophisticated response to the past adequacy question requires careful analysis of the complex relationships between investment, savings, and productivity and economic growth. The evidence on these linkages suggests that investment and savings were positive factors for productivity growth, but they were not the whole story. This conclusion generally applies to western industrialized countries. Other economic factors played a major role in the productivity and economic growth puzzles in Canada, including: the exhaustion of pools of underexploited knowledge available after the war; the rise of non-tariff barriers, as trade barriers were eliminated; changing labour force composition and growth; deterioration in the terms of trade; the rising costs of maturing social programs; Canada's poor record in fighting stagflation; and the instability of the international monetary system.

This does not mean that physical investment is unimportant for productivity growth. To the contrary; it is *a necessary but not sufficient condition for productivity and economic growth*. What does follow from these interrelationships is that improvements in investment and savings efforts must be part of a multifaceted effort to increase Canadian productivity and economic potential, innovation, skill development, capacity utilization, market access, and so on. This effort is necessary in order to address the many factors at play, as well as their complex interrelationships.

In this respect, there were a number of issues that are central to the way in which investment and savings efforts interacted with the other major economic factors affecting Canada's productivity and economic growth record. These issues included the development of human capital, R&D activity, the quality of investment, and the performance of Canadian financial markets.

Given the relatively sluggish productivity growth since the mid-1970s, there can be no other conclusion but that Canada could, and should, have done better. From this perspective, a fundamental lesson of the past concerns the quality of investment.

Canada's economic record demonstrates that there are open questions about the pace of innovation and the appropriate mix of capital formation, as well as about the way in which physical capital interacted with other major economic factors bearing on productivity and economic performance. It was in addressing and understanding these complex interrelationships that Canada, like most industrialized countries, failed to meet all the challenges.

CHAPTER 4
Canada's Future Investment and Savings Needs

CANADA'S FUTURE INVESTMENT AND SAVINGS NEEDS

This chapter addresses issues relating to the future adequacy of investment and savings efforts in Canada. While these efforts are necessary, however, they are not sufficient to ensure productivity and economic growth, and without them the Canadian economy will stagnate. It is important, therefore, to determine the order of magnitude of investment and savings efforts that is required to support Canada's future productivity goals. This quantitative question is addressed first in the chapter by presenting calculations setting out the possible range of required net and gross investment, depending on the desired rate of productivity growth, as well as capital/output and capital/labour ratios. Next, more qualitative areas - such as infrastructure, the environment, support of the aging population, and the external debt - are examined in terms of their pressure for additional investment. Where possible, quantitative estimates of investment needs are provided for those areas.

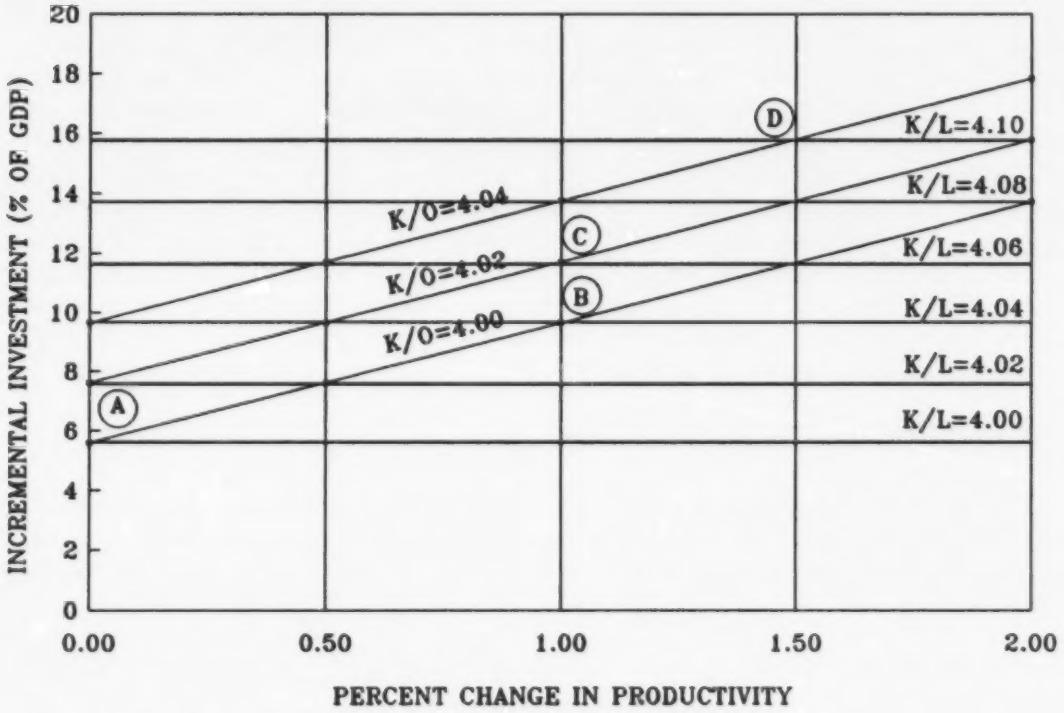
Projections of Future Output, Capital, and Investment

This section provides some calculations of the range of investment effort needed in the future to continue the long-run trend of modest increases in productivity growth (as measured by output per worker) and to permit relatively modest growth in capital, output, and income. At the outset, it should be stressed that capital/output ratios, which form the basis of the calculations, are at most rough and ready indicators of important long-run trends [see Kindleberger]. Their use for projections assumes continuity with past long-run trends in those grand relationships.

The section concludes by setting out low, medium, and high estimates of future investment effort. It should be noted that these estimates are predicated on productivity increases that are consistent only with the sluggish levels of the last decade and that will *not* put Canada on a growth path as high as that of the golden postwar years.[28] Moreover, these estimates do *not* consider any significant changes in the quality of capital resulting from technological change and innovation. Despite these relatively modest assumptions, the resulting investment effort in relation to current GDP appears substantial.

[28] Labour productivity growth averaged about 4 percent annually for the period from 1950 to 1973.

Chart 4-1
Incremental Investment Required at Selected Levels of Productivity and Specified Capital/Output Ratios*



* Estimates assume that the labour force increased by 1.4 percent.
Source: Estimates based on data from Statistics Canada; from M.C. Urquhart, *Canadian Economic Growth, 1870-1980*, Discussion Paper 734 (Kingston: Queen's University, 1988); and from David Swimmer, *Perspectives on Canadian Investment* (Ottawa: Investment Canada, 1989).

Chart 4-1 sets out a complete range of values of net incremental investment, depending on selected levels of productivity growth and specific capital/labour ratios.[29] Appendix E details the relationships in the analysis and sets out the mathematical equations involved. The logic underlying the calculations in this chart is as follows:

[29] The source data for this Chart and for Tables 4-1, 4-2, and 4-3 are from Statistics Canada, supplemented by Urquhart's estimates back to Confederation. The estimates do not take into account Jaffey's critique, discussed in Appendix A, that the stock of capital has been overestimated. The data are from the Urquhart and Swimmer papers cited in Chapter 2.

- As the labour force expands, investment is required to equip workers with the capital necessary to perform at the level of other workers. Increases in output also require that the entire stock of capital increase, which in turn leads to more net annual investment. Finally, given any particular capital/output ratio, any increases in productivity require net incremental investment. Since the accumulated stock of capital is several times larger than Canada's annual GNP or GDP, small increases in the stock require proportionately larger investment efforts. It should be stressed that given the relationships and the mathematical identity involved, there is *no causality implied*.

A number of assumptions were made to carry out this analysis:

1) It is assumed throughout that during the 1990s the Canadian work force will grow at an annual compounded rate of about 1.4 percent per year. This is in line with recent trends and forecasts.

2) Both Urquhart and Swimmer (1989) and earlier papers by Maddison (1979) show historical trends of increase in labour productivity and in real capital per unit of labour employed in Canada. Thus it is reasonable to assume that during the 1990s the capital/labour ratio will continue to increase.

3) For the starting point of analysis, the base real gross capital/output ratio at the start of the 1990s is taken to be 4.0.[30]

4) It is further assumed that for the starting point of analysis, labour equals 100 units of labour, and output (GDP) equals 100 units of output, which implies that the productivity level equaled one unit of output per one unit of labour.

Using these assumptions, the quantity of capital and incremental investment required in the future can be calculated, consistent with historical trends.

Chart 4-1 shows net incremental investment as a percentage of current GDP on the left vertical axis. The horizontal axis indicates the percentage change in labour productivity, measured in terms of output/labour (O/L). The right vertical axis shows the

[30] To derive the appropriate initial starting point for the capital/output ratio, residential and non-residential components were considered separately. Urquhart (1988) indicates that the real non-residential capital/GDP ratio was slightly over 3 in 1982 and 1983; however, a value of 3 was selected, since those were recession years in which the trend ratio was likely overstated (i.e., the denominator of GDP would be expected to be more depressed than the numerator of non-residential investment). He also indicates that the real residential capital/GDP ratio was about 1 at that time. Thus, for the aggregate projections in Chart 4-1, which include both residential and non-residential fixed capital, the base real gross capital/output ratio at the start of the 1990s is taken to be 4.

capital/labour (K/L) ratios necessary to support a corresponding level of productivity and capital/output (K/O). The sloping K/O lines represent the result of the change in the labour force, productivity, and the K/L ratio.

Points A, B, C, and D are illustrative examples to help the reader understand the combination of forces at play in Chart 4-1 and their sensitivity to changes. The values in Chart 4-1 are hypothetical but useful. They show that for rates of growth that are realistic for the Canadian labour force over the next decade, considerable net investment effort may be required even for modest growth in labour productivity (O/L) and the K/O ratio.

Labour force growth (Point A):

Relative to the starting point assumed, point A shows the effect of the labour force growing by 1.4 percent with no increase in productivity and a constant K/O ratio of 4.0. In essence, this point represents what would be required just to equip entrants to the labour force with the same amount of capital per worker as the existing labour force. The K/L ratio remains unchanged at 4.0 and the requisite incremental investment is 5.5 percent of the current GDP. In general, *every percentage point increase in the labour force requires 4.0 output units in incremental investment, or approximately 3.9 percent of current GDP.*

Labour force and productivity growth (Point B):

If, in addition to a growing labour force, it is assumed that *labour* productivity increases and the K/O ratio remains constant, then this leads to a rise in both the K/L ratio and the required incremental investment. For example, point B on the sloping K/O line (K/O=4.0) is achieved by labour force growth of 1.4 percent and a labour productivity increase of 1.0 percent. This causes the K/L ratio to increase from 4.0 to 4.04, which is also a 1.0 percent increase. The incremental investment required under these conditions is 9.4 percent of current GDP. This incremental investment would equip the labour force entrants with the average amount of capital per worker plus increase that stock of capital per worker by 1.0 percent. In addition, that would allow labour productivity to increase by 1.0 percent. Note that the only difference between points A and B is the assumption of a productivity increase of 1.0 percent. This labour productivity increase of 1.0 percent, however, requires an incremental capital/current-GDP ratio that is 3.9 percentage points higher. In general, *every percentage-point increase in productivity requires incremental investment of 3.9 percent of current GDP.*

Labour force, productivity, and K/O-ratio growth (Points C and D):

Now if, in addition to a growing labour force, both labour productivity and the K/O ratio are allowed to increase modestly in combination (point C), then the K/L ratio and the required incremental investment will rise by an even greater amount than in the previous example. At point C, the labour force has grown by 1.4 percent; labour productivity has increased 1.0 percent; and the K/O ratio has increased by a modest 0.5 percent (from 4.00 to 4.02). These conditions result in the K/L ratio increasing by 1.5 percent (from 4.00 to 4.06) and require incremental investment that is 11.4 percent of current GDP. Note that the difference in underlying assumptions between points B and C is simply an increase of 0.5 percent in the K/O ratio. The 0.5 percent, however, results in an incremental investment/current-GDP ratio that is 2.0 percentage points higher. Here, too, we can generalize that with all other factors held constant *every percentage-point increase in the K/O ratio requires incremental investment of approximately 4.0 percent of current GDP.*

Not surprisingly, the larger the projected increases in the K/O ratio and labour productivity, the larger the K/L ratio and the estimated net new investment effort. Point D of Chart 4-1 is based on the projected labour force growth of 1.4 percent, an increase in productivity of 1.5 percent, and growth in the K/O ratio of 1.0 percent (from 4.00 to 4.04). These conditions lead to an increase of 2.5 percent in the K/L ratio and would require incremental investment that is 15.4 percent of current GDP.

Gross Investment (Including Capital Replacement)

Although not reflected in the values shown in Chart 4-1, it is important to remember that investment effort is also required to replace capital that is used up or discarded. The historical rates of replacement have averaged 11 per cent of current GDP. Thus in the case of point D the suggested *gross*-fixed-capital-formation/GDP ratio would be 26.4 percent. This seems very high by recent Canadian historical standards, even though an increase in labour productivity of 1.5 percent may be viewed as lacklustre relative to the golden postwar years.

Residential or Non-Residential Investment

In Tables 4-1 and 4-2, non-residential and residential real capital formation are treated separately. It is important to distinguish between these two types of capital. The first concerns business investment, while the second deals with a type of capital that has traditionally involved relatively high investment effort. Furthermore, this distinction has practical benefits, as it permits us to vary the underlying assumptions for the two pools of capital and thereby arrive at a more precise range of estimates.

For this purpose, it is assumed that the real non-residential GDP or output in the base period is 80 and real residential GDP is 20.[31] Urquhart estimated that the ratio of non-residential to residential capital stock is approximately 3:1. This would imply base-period K/O ratios of 3.75 for non-residential output and 5.0 for residential output. These estimates are believable from Canada's experience.

Table 4-1
Estimates of Non-Residential Investment Needed for Assumed Increases in Productivity and Capital/Output Ratios

Percentage increase in:			Net investment as a percentage of GDP*
Labour productivity (O/L) ratio	Capital/output (K/O) ratio	Capital/labour (K/L) ratio	
0.0	0.0	0.0	4.1
0.5	0.0	0.5	5.6
0.5	0.5	1.0	7.2
1.0	0.5	1.5	8.7
1.0	1.0	2.0	10.1
1.5	1.0	2.5	11.6
1.5	1.5	3.0	13.1

*GDP estimate is based on calculated non-residential output, with residential output set at 20.28. This reflects no productivity increase for residential output, and labour force growth of 1.4 percent.
Source: Estimates based on data from Statistics Canada; from M. C. Urquhart, *Canadian Economic Growth, 1870-1980*, Discussion Paper 734 (Kingston: Queen's University, 1988); and from David Swimmer, *Perspectives on Canadian Investment* (Ottawa: Investment Canada, 1989).

Tables 4-1 and 4-2 show the estimates for the two pools of capital. In Table 4-2, estimates of the new investment efforts required to increase the residential capital investment stock were made using the same methods and assumptions underlying Chart 4-1.[32] These projections suggest net real business investment needs of between 4.1 and

[31] Imputed plus paid rents.

[32] Note that the changes in the K/O and K/L ratios are expressed with reference to percentage increases rather than estimated values.

13.1 percent of annual GDP. The bottom of the range appears to be unrealistically low, by Canadian historical standards, and the top is clearly on the high side.

Estimates of the growth in the net stock of residential construction were calculated, using the same set of assumptions as in Table 4-1. These estimates range between 1.4 and 4.4 percent of GDP, as shown in Table 4-2.

Table 4-2
Estimates of Residential Investment Needed for Assumes Increases in Productivity and Capital/Output Ratios

Percentage increase in:			
Labour productivity (O/L) ratio	Capital/output (K/O) ratio	Capital/labour (K/L) increase	Net investment as a percentage of GDP*
0.0	0.0	0.0	1.4
0.5	0.0	0.5	1.9
0.5	0.5	1.0	2.4
1.0	0.5	1.5	2.9
1.0	1.0	2.0	3.4
1.5	1.0	2.5	3.9
1.5	1.5	3.0	4.4

*GDP estimate is based on calculated residential output, with non-residential output set at 81.12. This reflects no productivity increase for non-residential output, and labour force growth of 1.4 percent.

Source: Estimates based on data from Statistics Canada; from M. C. Urquhart, *Canadian Economic Growth, 1870-1980*, Discussion Paper 734 (Kingston: Queen's University, 1988); and from David Swimmer, *Perspectives on Canadian Investment* (Ottawa: Investment Canada, 1989).

The Range of Estimated Gross Investment Needs

Table 4-3 provides a range of estimates of future gross investment requirements expressed as a percentage of GDP, based on the values in Tables 4-1 and 4-2. These estimates depend on the underlying assumptions and fall into three general categories - low, medium, and high. As before, all estimates assume labour force growth of 1.4 percent.

Low Estimate

The low estimate was constructed assuming that labour productivity for non-residential output increases by 0.5 percent, with the capital/output ratio increasing by 0.5 percent as well. For the residential output component, the same set of assumptions were used. Note that the increases in the non-residential and residential capital/output ratios were less than the average annual changes recorded in the last decade (0.63 and 1.25 percent, respectively).

It is clear that the low scenario is unsatisfactory, as it assumed labour productivity growth to be just below the sluggish levels of 1988 and 1989, which averaged 0.65 of a percentage point. This low scenario is sufficient to equip a growing labour force with the same amount of capital per worker as the existing labour force and a little more to support the small increase in productivity growth.

Medium Estimate

The medium estimate has productivity for the non-residential labour component increasing by 1.0 percent, with the non-residential capital/output ratio expanding by 0.5 percent. Note that the increase in the capital/output ratio is equivalent to that used in the low estimate - less than the average annual growth of 0.63 percent experienced in the last decade.

In the case of residential output, labour productivity was also increased by 1.0 percent, but the residential capital/output ratio increased by 1.0 percent. This estimate of labour productivity growth is somewhat lower than that of the last decade, which averaged about 1.5 percentage points. While the increase in the residential capital/output ratio is greater than the low estimate, it is still less than the average annual increase (1.25 percent) experienced in the last decade.

Relative to the low estimate, there is some additional investment effort to support the higher, but still modest, increase of 1.0 percent in productivity. This productivity

increase, while larger than that seen in 1988 and 1989, is substantially below the productivity growth of the last decade (1.5 percent) and would place Canada at the bottom of the G-7 listing.

High Estimate

The high estimate assumes that labour productivity increases by 1.5 percent for non-residential labour and that the capital/output ratio expands by 1.0 percent. While the increase in the capital/output ratio is slightly larger than the average annual increase experienced in the last decade, it should be noted that since 1960 every decade has seen an improvement in the average annual growth of this ratio.

In the case of residential output, labour productivity is also assumed to increase by 1.5 percent, but the capital/output ratio increases by 1.5 percent. Note, again, that while the increase in the residential capital/output ratio is marginally greater than the average annual increase of the last decade, every decade since 1960 has demonstrated an improvement in this ratio.

This scenario assumes productivity growth equivalent to the *status quo* of the last decade and increases in the capital/output ratios that are in line with historical trends.

Summary of Estimates

To summarize, the estimates of future gross investment efforts range from a low of between 20.6 and 23.0 percent to a high of 26.9 percent of current GDP. All three estimates appear to be disappointing targets if labour productivity growth is deemed essential. While the medium and high estimates seem optimistic in terms of historical investment effort, only the high estimate is consistent with the status quo of labour productivity growth and the historical improvement in the capital/output ratio. Recall that Canada's historical investment averaged a bit over 23 percent between 1955 and 1980, and under 23 percent in the 1980s.

While the productivity growth rates on which these estimates are based are not remarkable, it is clear from the calculations that ***relatively small changes in labour productivity growth have substantial implications for future investment needs. These relationships assume that there are no changes in the growth rates of total factor productivity or in the differential productivity of various vintages of investment - issues that are beyond the scope of this paper.***

Table 4-3
Range of Estimated Gross Investment Requirements*
for Assumed Increases in Productivity

Range of estimates	Incremental investment		Percentage increase in labour productivity	GDP	Gross annual investment (% of GDP)
	Non-residential	Residential			
Low	7.4	2.4	0.5	101.9	20.6
Medium	8.9	3.4	1.0	102.4	23.0
High	11.9	4.5	1.5	102.9	26.9

*Estimates assume capital replacement to be at 11 percent of GDP. They are not additive with Tables 4-1 and 4-2, which, in analysing one type of output, hold output constant for the "other" pool of capital.
Source: Estimates based on data from Statistics Canada; from M. C. Urquhart, *Canadian Economic Growth, 1870-1980*, Discussion Paper 734 (Kingston: Queen's University, 1988); and from David Swimmer, *Perspectives on Canadian Investment* (Ottawa: Investment Canada, 1989).

Efforts Required to Meet Additional Needs

This section questions whether the continuation of past trends of investment efforts would be sufficient to satisfy the anticipated needs relating to infrastructure, the environment, and sustainable economic growth, as well as Canada's external debt problem. Unlike in the previous section, many of these needs affect the residual of productivity growth and potential TFP growth.

Infrastructure

Despite national gross investment efforts in Canada having ranged between 21 and 23 percent of GDP during the last couple of decades, it is popularly argued that the existing infrastructure has deteriorated, and improvements have not kept pace with public requirements. There is much visible and anecdotal evidence to support this conclusion, but there are few reliable quantitative estimates of the shortfalls and of the investment effort needed over the next decade to deal with them.

Swimmer (1990) reports that: "relative Canadian expenditures on new and repair construction infrastructure decreased from the mid-1970s to the present. During 1977 they comprised 2.8% of GDP, but have slipped as low as 1.6% in 1987 before rising to 1.8% in 1989."

The fact that government investment has been growing less rapidly than business investment for many years does not, by itself, establish the inadequacy of investment in infrastructure. As demographic growth has slowed, so has the need for more schools, colleges, and universities. As urban growth has slowed down, so has the need for new urban services. Replacement and some new installations are still required, but the pressure for net additions appears to be somewhat less than in the peak public-investment periods of the 1960s and 1970s.

Swimmer quotes some results from a survey by the Federation of Canadian Municipalities in 1985. While the figures shown in Table 4-4 are probably exaggerated, the priorities indicated are interesting. Swimmer also reports the costs of postponing the maintenance of roads, suggesting exponential rates of deterioration and exponential increases in the unit costs of maintenance.

Table 4-4
Status of Infrastructure in Canadian Municipalities, 1985

	Infrastructure reported to be in need of repair or replacement (% responding)
Roads	70
Sidewalks	57
Sewers	55
Bridges	49
Sewage treatment	40
Storm sewers	35
Water distribution	32
Solid waste disposal	30
Parks	23
Buildings	20

Source: David Swimmer, *Infrastructure* (Ottawa: Investment Canada, 1990, unpublished).

The Federation of Canadian Municipalities and the Good Roads Association keep pressing both the federal and provincial governments for a much expanded program of support for renewal and improvement of infrastructure.

In recent years, two major economic arguments have emerged concerning investment in infrastructure. The first was stimulated by the work of David Aschauer, formerly of the Federal Reserve Bank of Chicago, and was followed by hundreds of related papers. This body of work purported to show that investment in infrastructure has been, and still is, a major contributor to the productivity of investment in general and to growth in productivity. The most useful compendium of this work was edited by Alicia Munnell and published by the Federal Reserve Bank of Boston in 1990. While the consensus that has emerged is that the effects alleged by Aschauer and some of his disciples are exaggerations, there is widespread acceptance that infrastructure is a positive contributor to economic growth, both directly and through enhancement of the productivity of private activities. Charles Schultze and Henry Aaron of the Brookings Institution have been the leaders in de-escalating the Aschauer claims.

The other main economic argument about investment in infrastructure concerns efficiency of investment and use. This is a distinct issue, but at some points it is intertwined with the issue of aggregate needs for investment in infrastructure. If efficiency in investment and use of infrastructure could be substantially increased, then a given stock of infrastructure would meet a larger set of infrastructure needs of an economy or a region. The efficiency arguments have been most highly developed for highway and air transportation, with the leading work having been done by economists associated with the Brookings Institution, including Winston, Small, and Evans. Highways, including urban street systems, and air transportation facilities are a large proportion of the total infrastructure stock in industrial countries. Research has shown that congestion pricing for the use of highways and airports, axle-load pricing for the use of highways by trucks, and some changes in the content of investment in highways and airports could bring about large increases in the efficiency of investment and use of transportation facilities in the United States. At the technical level these arguments command widespread support in the United States and Canada; so far, however, the political limitations on the implementation of their proposed institutional changes have been severe.

An important conclusion of these two examinations of infrastructure is that even if considerable improvement could be achieved in the investment and its use, both Canada and the United States would benefit more from a larger investment effort in infrastructure than they have during the last decade. Nevertheless, Canadian needs and demands by municipalities should be examined with the same skeptical eye that Schultze casts on U.S. representations.

Environmental Needs

Even less is known about the investment needed to repair or reduce accumulated environmental degradation than about that needed to improve public and private infrastructure. To the casual observer, deficiencies in sewage treatment and disposal

capacity appear severe in some areas - Halifax harbour, Montreal, and Ottawa. Accumulations of toxic waste in burial sites and waterways are large and appear to be growing. Forests and lakes are still deteriorating from acid rain. Even more worrisome is the "greenhouse effect" on climate that arises from the emission into the atmosphere of trace gases, particularly carbon dioxide, mainly from the burning of hydrocarbons. The amount of investment needed to right the accumulated degradation is unknown.

Carl Sonnen, in Informetrica's *Monthly Economic Review*, May 1989, reported and evaluated some evidence on the costs of meeting specified environmental standards for Canada between 1990 and 2000. This draws on, and develops, measures from a 1989 study for the Ontario Ministry of Energy on the reduction of energy-related greenhouse gas emissions, as well as other studies. While not comprehensive, the report covers a wide range of possible actions for business, household, and government sectors in Canada.

These estimates indicate additional capital expenditures of $70 billion, in 1989 prices, to meet a substantial range of environmental initiatives over the decade. This total is about 2.4 percent of the existing capital stock for all sectors. To make good these expenditures during the decade would require, by the year 2000, incremental annual expenditures of about 1.8 percent of GDP for the sectors covered. The burdens would vary widely among industries and government sectors. To put this into perspective, the additional investment expenditures to meet the proposed environmental standards would be equivalent to 15 to 20 percent of historical-trend averages of net investment.[33]

Sonnen therefore suggests that a phased program over the 1990s of 4 to 5 percent of recent annual (gross) investment flows may be required. The implication is that the burden of meeting the environmental standards will be heavy but far from intolerable. Put another way, it appears that substantial improvement in meeting good environmental standards would require, at one extreme, a sacrifice from consumption of a few decimal points of annual productivity growth or, at the other extreme, the addition of a few points of annual productivity growth, which would permit sustained improvements in consumption or other uses of the nation's product.

Sonnen compares the large incremental expenditures that may be needed for environmental improvement with those that may be needed to maintain and improve the health care system, to deal with literacy problems, and to improve child care in Canada. He estimates that health care and literacy may each require incremental expenditures as large as those to meet the environmental initiatives.

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[33] Recall that net investment efforts have averaged about 9 to 12 percent of GDP.

Support of the Aging Population

The proportion of the Canadian population aged 65 and over will increase during the next three decades. Most of these people will no longer be in the active labour force and will need support.[34]

At present, and under policies for the immediate future, income for the aged is, or will be, derived from a number of sources:

- the Old Age Security (OAS) and Guaranteed Income Supplement (GIS), which are universal (but now subject to the so-called "clawback") and unfunded;
- the Canada Pension Plan (CPP) or Québec Pension Plan (QPP), which applies to a large fraction of the work force, with benefits limited by the average industrial wage, and which is funded only to a limited degree;
- employer-based pension plans, most of which are fully funded but provide good entitlements to only a small proportion of employees;
- the proceeds from a Registered Retirement Savings Plan (RRSP) and/or Registered Retirement Income Fund (RRIF);
- private assets, including owner-occupied housing, investments, equity in life insurance policies, annuities; and
- some earned income.

The benefit levels, measured as a proportion of terminal earned income, are quite low for a large fraction of the population. Many people, particularly older women, have no pension income other than OAS and GIS.

Even if benefit levels are not improved, the proportion of the national income that will be needed to provide retirement income will increase substantially because the number of people over the age of 65 is growing more rapidly than the labour force. For example, maintaining the benefit levels of the CPP/QPP would require, even with the current partially funded policies, an increase in employer/employee combined contribution rates from about 3.6 percent to 7.2 percent of payroll up to the average

[34] See Economic Council of Canada, *Legacies*, for a useful, up-to-date discussion of aging and retirement income.

industrial wage. This will require a gradual increase in contribution rates over two decades. Improvements in coverage and benefit levels would accentuate the increase in the burden resulting from the demographic changes.

The U.S. social security system has wider coverage and higher benefit levels than the Canadian OAS/GIS/CPP/QPP program. Also, the contribution levels place it on a much more nearly funded basis. Even so, Schultze has indicated that U.S. savings and investment efforts in the future should be increased to cope with the increased burdens of the aging population. He recommends a target of 2.5 percent of national income as the *additional* savings needed for future retirement needs. Compared with his target base level savings in the United States of 5.3 percent of national income, the addition is astoundingly large. The logic of the argument is that such additional savings will increase income growth and levels in the United States, compared with whatever they would otherwise become, and that it will be possible and tolerable for the increased burden of retirement needs to be met out of such an enlarged income.

Estimates are not available of comparable Canadian figures and targets. But given the similarity of Canadian and U.S. demographic trends, and the degree of underfunding of Canada's basic pension plans, the additional savings needed for future retirement needs for Canada must be at least as large as the targets suggested by Schultze for the United States. Canadian savings arising from RRSPs are larger, however, than those from similar U.S. programs, which is a favourable factor for Canadian retirement income.

External Debt

In recent years, Canada has relied increasingly on foreign savings. This is mainly because national savings efforts have fallen short of national investment efforts, even though the latter have not been exceptionally large. The main reason for the shortfall has been the shift of government saving to dissaving.

Until the late 1970s, it was difficult to argue that external debt service was much of a problem for Canada. Net foreign indebtedness was less than 30 percent of GNE and was not growing. In recent years, however, net foreign indebtedness has been increasing faster than GDP, and real interest rates on the debt have also been increasing.

External debt service must ultimately be met by exporting more goods and services than are imported, apart from the debt service. To put it another way, Canada will have to produce more than it absorbs or uses in consumption and investment for a period of years in order to meet the real burden of the debt service.

To stop the *growth* of the foreign debt-servicing burden, Canada will have to reduce its current net ratio of foreign capital imports to GDP or find lower interest rates

on the foreign debt, or both. Reductions of government dissaving, as contemplated in the federal deficit-reduction program, can contribute towards that objective.

A case can also be made for reducing, in proportion to the GDP, the burden of servicing the net debt that has accumulated in recent years. This would require an increased savings effort or a reduced domestic investment effort. But it has already been argued that the target for investment effort may have to be higher than past average levels in order to achieve economic growth, improve infrastructure, meet environmental needs, and cope with the needs of an aging population. Thus if the relative weight of servicing the accumulated net Canadian foreign debt must be reduced, Canadian savings effort may have to be increased. Also, exports will have to be expanded relative to imports, suggesting the need for better access and competitiveness of Canadian production in international markets.

CHAPTER 5
Data, Theory, Speculation, and Further Research

DATA, THEORY, SPECULATION, AND FURTHER RESEARCH

Why such a strange title for this chapter? To what jumble of enquiries does it point? What are the connections to the main body of this paper? While a good deal of confidence is held in the story of the preceding chapters, at this stage there are important gaps and limitations to the story. With more information and more research in the future, these gaps and limitations may be reduced. It is important to understand some of the issues, not only to avoid misinterpretations but to point the way to future work.

Some of the gaps and limitations arise from the data on investment, saving, the stock of capital, growth in the economy, and interrelationships between the factors involved. Some arise from conflicting theoretical models, of which a few are novel. Some arise from the inherent problems of analyzing change over long periods of time, particularly in distinguishing the transitory from the enduring changes. Others arise from changes in the circumstances and policies of countries, for which analysis always involves uncertainties.

Still other gaps and limitations arise from particular Canadian factors; however, many of these are common to western industrialized economies. Tremendous interest has arisen, and much new research on economic development has recently taken place, particularly in the United States and Europe. Many of these studies involve cross-country and cross-regional comparisons, which - at least potentially - can help to explain Canada's experience. A major concern in most of these studies is the measurement and explanation of "the residual" - namely, the portion of economic growth that is over and above that which could be attributed to increases in the labour force and the capital employed.

This chapter outlines briefly some of the gaps and limitations in our main story, discussing in turn:

- Canadian data;
- the development and testing of growth theories;
- the possible enrichment of the analysis of growth by adding micro research to the usual macro-level enquiries;
- the temporary and more enduring changes in Canadian circumstances and policies; and
- the most important and most promising future research on growth in Canada.

Measurement Data

The Canadian data used to measure the national output, investment flows, the stock of capital, labour, and total factor productivity have been very substantially revised in recent years. Based on the older data, a story of modern Canadian investment and growth had emerged in recent years. The revised data do not alter that story's qualitative conclusions; however, many of the quantitative relationships have changed.

Three of the four main types of data revisions made by Statistics Canada affected the aggregate comparisons dealt with in this paper:

1) Reflecting surveys on the lives of various kinds of capital assets (but not the Jaffey proposals), *the expected lives of capital assets were drastically reduced*, particularly for machinery and equipment. In addition, there is an unsettled debate over the appropriate rate of depreciation of the stock of capital over time. Accordingly, Statistics Canada provides for three methods of depreciation in determining the net stock estimates for the 1980s. The main effects of the reductions in the expected lives of assets have been to reduce the measured current- and constant-dollar real stock of capital, particularly the net stock of capital, in comparison with the older measures. Thus for the net stock of capital, in particular, the levels of the capital/labour and capital/output ratios referred to in the Urquhart and Swimmer papers were substantially reduced for the 1980s. By interpolation, the measured levels of the capital stock prior to 1980 have been adjusted by Statistics Canada to the newer estimates for the 1980s.

2) *The price indexes used to convert current- to constant-dollar investment in stocks of machinery and equipment were sharply reduced in the 1980s*. These revisions arose mainly from drastic reductions in the real cost of computing power and related investments. Taken by themselves, for any given current-dollar outlay on machinery and equipment, the effect is to increase the constant-dollar expenditure and the gross and constant-dollar net stock of capital. These effects are the opposite of those resulting from the previous revisions, in the sense of increasing the measured constant-dollar stock of capital, particularly in the form of machinery and equipment.

3) Late in the 1980s, *the National Accounts were rebased from 1981 to 1986 by Statistics Canada*. The rebasing, beginning from 1980 on, introduced non-trivial changes in the measured growth rate of the real GDP for Canada in the 1980s and in the relationship of the components of GDP. The rebasing also took into account the two other types of revisions set out above.

One of the main consequences of the rebasing is the discontinuity of growth and other measurements for the period after 1980 and before 1980. Moreover, some

inconsistencies between the before- and after-1980 measurements of capital/output, capital/labour, and total factor productivity ratios cannot be eliminated. This is one of the classic problems with index numbers; only more or less defensible linking of time series on various bases is possible. It would be inappropriate to revalue the output or the stock of capital in the early 1960s on the basis of the price structure of the 1980s. The latter is heavily influenced by the prices of computing - an activity of trivial proportion in the early 1960s. It would be just as inappropriate to revalue the output or the stock of capital of the 1980s using the price structure of the 1960s. The best that can be done is to make chain links of the series constructed on various bases. An extensive technical literature on this subject exists, particularly with respect to cost-of-living indexes.

The important point for this paper and related work is to be aware of the discontinuities and to take them into account in interpretations. For example, the linked series on the net real stock of capital over the whole period from the mid-1960s to the end of the 1980s appears to exaggerate the degree of growth in the machinery and equipment stock used by the business sector in Canada. Even when allowance is made for this statistical problem, however, the structure of investment did shift strongly towards machinery and equipment. As another example, the slowdown in measured productivity growth between the late 1970s and the early 1980s also appears to have been exaggerated; but even when making allowances for the discontinuities, a slowdown did occur.

Statistics Canada also made a fourth revision in the industry detail for productivity analysis, providing information on various alternative concepts of industry output and on various scopes of related inputs. These data do not affect the aggregate measures that have been the main concern of this paper, nor are they examined here. They do, however, open up possibilities for enlightening research on a micro-industry basis and may ultimately provide some new insights on the aggregate productivity measures themselves.

The data revisions do warrant some cautionary notes for this and other papers on the subject. For example:

- It is important to recognize the discontinuities in data for the years before and after 1980, and the need for caution in drawing conclusions from comparisons of before- and after-1980 measurements. Nothing can be done to eliminate all these discontinuities; some of them are the inevitable by-product of using index numbers. These difficulties are seldom mentioned, even in the analytical literature on Canadian economic growth. They almost never appear in the popular literature on growth. This is understandable, because they are somewhat arcane

technical matters. Nevertheless, they should be noted, because they have important effects on the interpretations of Canadian economic development.

- Many of the revisions are tentative in nature because of the inherent weakness in the data bases on which they are constructed. This is particularly so for the expected lives of capital assets and the price adjustments for machinery and equipment. Jaffey's proposals for new approaches to measurement of the stock of capital are also moot. Internationally, countries appear to be at different stages in making the kinds of revisions that have been introduced already in Canada - a factor to be taken into account in international comparisons.

- The debate is still unsettled as to the appropriate method of depreciation (geometric, straight-line, or delayed) that should be applied in the national accounts and in the measurement of the stock of capital.

- It is still undecided as to the appropriate weights to apply to labour and capital inputs in reckoning total factor productivity. Statistics Canada describes their measures of total factor productivity (or multifactor productivity) as "experimental". Maddison (June 1987) recently reviewed the weighting used in a number of national and international studies of productivity.

- There are unsettled issues over the use of unadjusted or "augmented" measures of labour and/or capital in productivity analysis (also reviewed by Maddison in June 1987). Most of the work on productivity and growth is based on unadjusted measures (labour, in the number of persons employed, or hours; and capital, in dollars) that do not take account of vintages. From this work, large residuals arise in total factor productivity.

- Some researchers, however, take the view that the measures of labour should take account of the changing quality of labour inputs - for example, because of the increasing educational attainments of the population. Some, though fewer, researchers try to "augment" the capital inputs by allowing for the improving quality of elements making up the stock of capital. Research work that introduces such adjustments generally shows smaller residuals of total factor productivity.

- Important qualifications should be attached to the research work that make adjustments to one or more of the factor inputs. The precise measurement of any such augmentations are controversial. For example, the relationship between education and labour productivity is far from precise. Thus the residual growth in productivity - i.e. the growth not resulting from increases in the quantities of inputs - may be reduced only at the cost of uncertainty and confusion in measuring inputs. Most researchers prefer not to work with augmented inputs;

instead, they examine the effects of qualitative changes in inputs explicitly and directly.

The Testing and Development of Economic Growth Theories

A resurgence of interest in economic growth occurred in the 1980s. In part, the interest arose from concerns addressed in *The Rise and Fall of Great Powers*, by Paul Kennedy, and in *Bound to Lead: The Changing Nature of American Power*, by Joseph Nye. More recently, the growth problems of the Soviet Republics and Eastern Europe have sparked further public interest. On a more mundane level, the media and the public - particularly in Canada and the United States - have been concerned about trends and the prospects of slow growth in productivity and good jobs, in exports and income, and in the future standard of living for themselves and their children.

Whether or not they have been stimulated by this public interest, a parallel resurgence of research into economic growth has taken place by students of economic development, as well as economic historians. Macro economists have turned to the subject; so have scholars of industrial organization. Business school researchers, who generally focus on micro issues of firms and industries, have also attempted to generalize their conclusions and advice to aggregates such as regions and nations. Most of the resurgence of research into economic growth has been planted within orthodox theories, the novelty having arisen from new and richer evidence on old issues. Major new contributions have been made by Abramovitz, Maddison, Solow, Baumol, Helliwell, Barro, and Williamson. These contributions will be cited briefly here. Some of these works have been labelled *new theories of growth*, including the work done by Harris, Lipsey, Reich, Porter, and Rugman, to which brief reference will also be made here.

One of the most useful overviews of the research on growth is in *Productivity and American Leadership: The Long View*, by Baumol, Blackman, and Wolff, and in a review article on that book by Jeffrey Williamson in the *Journal of Economic Literature*, March 1991. A number of important messages for this analysis can be found in that literature, including the following:

- Recent productivity experience must be put into a long-term perspective, such as the last 100 years. From this view, the growth experience of wartime and the postwar period through to the early 1970s was exceptional, not the long-term norm.

- The convergence of the productivity levels of the western industrialized countries towards the U.S. level is not a reflection of a long-run slowdown in productivity growth in the United States; rather, it reflects the higher long-run productivity growth of the other industrialized countries. Baumol *et al.* argue that, although there have been variations in the trend, the long-run trend of U.S. productivity

growth has neither increased nor decreased from a norm of about 2 percent per annum, compounded. The long-run trend of productivity growth for what are now called "other advanced capitalist economies" has been higher, but in many cases from lower historical *levels*.

- The United States has been losing its **relative** productivity leadership throughout the postwar period. The interesting question, however, is why it has retained its **absolute** leadership so long. Also interesting is the fact that the relative deterioration in productivity leadership does *not* imply a decline in U.S. economic welfare.

- The explanations of the long-run aggregate growth performance will be greatly enriched by comparative international studies of particular industries, such as iron and steel.

- The U.S. productivity growth in the first part of the 1980s was below long-run historical rates, but there is considerable evidence that this may have been a transitory situation.

- Capital accumulation has been strongly correlated with long-run growth. High rates of capital "deepening" in inanimate forms have been associated with periods of U.S. leadership in productivity growth. One of the main questions addressed by Baumol *et al.* and Williamson is why capital deepening has continued to be so strong in the United States. They offer, as a partial explanation, the relative cheapness of capital goods in the United States, compared with other countries. Nevertheless, there is much more to the United States growth story than capital accumulation.

- Capital formation in the United States has historically comprised both foreign and U.S. savings. In recent decades, however, the saving/investment relationships for the United States have been the subject of major disagreements among scholars and policy-makers. The U.S. personal savings, as conventionally measured, have become a small proportion of personal disposable income. In addition, U.S. governments have become large dissavers. The U.S. dependence on net international capital inflows has become considerable. The U.S. business investment effort has declined, but not by all that much. Whether or not these relationships are viable over the medium to long term is unsettled? For those who think not, major disagreements exist as to the causes and cures.

- Investment in human capital in the United States has increased and has become a more important contributor to U.S. productivity. Such investment appears to explain partly the anomalies in U.S. growth. Saving for investment in human capital is not fully measured in conventional national accounts; thus lower

measured personal savings efforts appear to be partly compensated by higher (unmeasured) personal savings and investment in human capital.

The research studies on economic growth by Baumol *et al.*, Williamson, Maddison, and others are set in the orthodox frameworks of neoclassical growth theory and the theory of international trade. Both of these are being challenged - or at least substantially amended - by other theoretical frameworks.

One challenge arose from the unsatisfactory explanations that the orthodox theory of comparative advantage and international specialization provided for patterns of world trade. Under that theory, countries would, and should, specialize in the production and export of those products in which they have a comparative advantage. Since capital and ideas were mobile internationally, comparative advantages would be based on those factors of production that were relatively plentiful - land and particular resources, and skilled labour. This theory turned out to be a quite satisfactory explanation of specialization and trade in primary products.

The theory turned out, however, not to be a satisfactory explanation of trade in manufactures. Comparative advantages in particular kinds of manufactures appeared to be based on leadership in the application of new technology, and in those activities in which learning curves were important, on economies of scale and scope, and so on. Vernon's early work on product cycles helped to explain these comparative advantages; but deeper questions were raised. What explained leadership in the application of new technology, early starts on learning curves, more or less successful exploitation of economies of scale and scope, or a nation having more of the successful firms in an industry? What conditions are more or less favourable for gaining those comparative advantages? What can a nation, or a region, do to create and improve these comparative advantages or to improve its competitiveness?

In Canada, the research on these issues is well beyond "infancy" but well short of "maturity". It requires the involvement of research on industrial organization, as well as international and interregional trade, labour economics, innovation, and research and development. It requires the integration of evidence on firms, as well as industries and larger aggregates. It requires the integration of case work and the analysis of firms, which has been the focus of business school researchers, as well as the group (or more aggregate) analysis, which has been the focus of economists. Among the economists contributing to these new or revised theories of economic growth are: economic historians, such as McInnis and Green; and economic generalists, such as Safarian, Harris, Lipsey, McFetridge, Waverman, Ostry, Whalley, Daly, Gorecki, Baldwin, Litvak,

Borins, Maule, Acheson, and Matthewson, to name a few. Among the business school researchers, important contributions have been made by Stanbury, Fleck, deCruz, and Rugman.

Lipsey has summarized the important features of the new growth theories. They "recognize technological innovation as an endogenous process. . . . These theories show innovation as idea-based and are thus to provide benefits freely to others than those who paid to develop them. This results in increasing returns to innovations. . . . since the existence of increasing return is incompatible with perfect competititon, aggregate growth models now use models of imperfect competition" [Lipsey, May 1991, p. 9]. As has been emphasized in this paper, though capital accumulation is important to growth, the analysis of, and policies for, economic growth require more far-reaching research.

Another important policy issue raised by recent theories of economic growth concerns the possibility of a substantial gap between the private and social returns to saving and investment. If there are technological externalities or increasing returns associated with the production of capital goods, then the social cost of forgoing increased investment may be very high. Lawrence Summers (1990) also raises the possibility that partial expropriation of rents by labour inhibits investment, thereby driving a wedge between the social and private returns.

Changes in Canadian Circumstances and Policies

Several changes of relevance to Canadian economic growth and productivity have not been considered in this paper, in the belief that they were not paramount to the investment/saving macro growth and productivity story. In a more complete analysis, some of these policies should be investigated. The topics include:

- the effects of the Free Trade Agreement, the Goods and Service Tax, and deregulation - policy changes introduced in the 1980s and intended to improve the medium- to long-run economic growth of Canada;

- the effects of shifting funds from some programs of income support and supplementation towards training and retraining - intended to enhance the efficiency and growth of the economy by improving the human skills available and altering incentives towards work;

- the effects of revised immigration policies, one of the objectives of which is to improve the supply of needed skills and efficiency; and

- the short-term pain associated with policies aimed at reducing substantially and rapidly the average inflation rates in Canada, and the long-term gains attributed to such policies.

Canadian investment in human capital, research and development, and marketing are not examined in this paper, partly because the data available are so limited. Public concerns about these issues are increasing, however, so additional research is needed. For example, while the amount of dollars spent on education per capita is high in Canada compared with most other industrialized countries, there is widespread doubt that Canada is receiving from that effort what is required to be competitive in a global context. Again, there has been concern for some time that Canadian entrepreneurs do not generally measure up to those in countries such as the United States, Japan, and Germany, with which Canada has to compete. This is not the place to review and evaluate Michael Porter's new study, *Canada at the Crossroads*; it is appropriate, however, to note his argument that the Canadian problem requires better investment. "Better" involves reallocation towards technology, innovation, skill developments, more competitive markets, and research and development.

Moreover, this paper has been almost exclusively macroeconomic. Regional and sectoral analysis of investment, capital, productivity, and growth would be desirable. Regional and sectoral shifts should be studied not only for what they reveal of past trends but as a means of examining prospects. Indeed, some growth theories, such as that of Rostow, make sectoral developments central to the analysis.

Promising Areas for Future Research

A number of areas for future research appear to be most promising in light of this paper. They include:

- a long-term comparison of Canadian and U.S. economic growth, paralleling the recent study by Baumol *et al.*, as reviewed by Williamson;

- following the suggestion of Williamson, the enrichment of macroeconomic growth and productivity analysis in Canada by studies of firms and industries, and also consideration of favourable and unfavourable changes in world prices and market access;

- a more complete study of trends in Canadian saving, expanding on the brief comparative material in the recent Brookings study of U.S. saving by Bosworth *et al.*;

- increased research on technological change, innovation, and industrial organization and trade, along the lines being pursued by Richard Lipsey;

- a resurgence of research on human capital and the integration of that research with other kinds of work on productivity and growth - in particular, there should be concern for the improvement of incentives related to Canada's programs of income support and supplementation;

- further research along the lines explored by Sylvia Ostry in *Governments and Corporations in a Shrinking World*, which deals with the growing divergence between the powers, interests, and activities of corporations and of governments;

- a major effort to understand the "residual" in productivity growth (i.e. the growth not attributable to increases in the working population), the stocks of capital, and the macro investment and savings efforts of nations and regions. What can be done to improve total factor productivity growth? What is the appropriate sharing of the benefits and costs of such improvements in productivity?

- perhaps most important of all, the complexity of the various factors in the TFP residual and their interrelationships, as they continue to plague the science of economics. The challenge, therefore - in order to understand the multifaceted productivity story - is to make real progress in the methodology used to derive TFP and in its interpretation. Canadians, like researchers in other industrialized countries, still have much to do.

CHAPTER 6
Conclusions

CONCLUSIONS

Three questions were posed in the introduction to this study.

1) ***Have weak Canadian investment and/or savings efforts been a major factor in the unsatisfactory Canadian productivity growth of the past 15 years?***

Weak investment effort has been a contributing factor, but other economic factors interacting with investment have also had a great influence. A main lesson of the past concerns the quality of investment in Canada. Above all, Canada, like other industrialized countries, failed to address, and understand, the complex ways in which physical capital interacted with those other major factors lying behind the productivity and economic growth puzzles.

The evidence on productivity, investment, and savings efforts among western industrialized countries generally points towards these answers. After a golden era of exceptionally high productivity growth and investment and savings efforts among industrialized economies, all these elements were reduced after the mid-1970s. While the correlation between high-investment economies and high productivity growth over the long run can be established, the deterioration in investment and savings efforts in western industrialized countries was not sufficient to explain the drop in productivity and economic growth that began in the 1970s. Innovation and other factors mattered a great deal too.

Canada's productivity performance relative to that of other countries during the postwar period can be singled out in terms of the strong rate of labour force growth, the deteriorating record of labour productivity in manufacturing, and the slow and unstable TFP growth in the 1980s. Relative to other countries, Canadian investment appears high in the 1980s, mainly because investment efforts declined in other countries.

More than in other industrialized countries, the reduction of investment effort in the 1970s and 1980s in Canada therefore does not fully explain the much larger decrease in rates of productivity growth. Capital accumulation was relatively high, although, more than in other countries, it was destined to capital widening to allow for its rapidly expanding labour force. Along with innovation, other factors that carry a good deal of weight include the exhaustion of pools of underexploited knowledge available after the war, the emergence of non-tariff trade barriers, the changing labour force composition and growth, which led to fewer opportunities for expansion, the deterioration in Canada's terms of trade, the costs of maturing social programs, Canada's poor record in fighting stagflation, and the instability of the international monetary system. Moreover, there appear to be particular problems with machinery and equipment investment in Canada.

Although it was high in the 1980s, machinery and equipment spending did not translate into the expected innovative practices that contribute to productivity growth.

In Canada, national savings efforts were relatively satisfactory throughout the postwar period. Canadian private savings efforts were notably well maintained in the middle ranks for western industrialized economies; in most years, net personal savings represented a larger proportion of net total domestic savings than business and government savings combined. There was, and is, a solid core of Canadian personal savings committed by contract to life insurance, trustee pensions, and registered retirement plans.

Although Canada continued to be a modest net capital importer during much of the postwar period, the marked shortfall of Canada's savings effort below the national investment effort was worrisome in the 1980s. The principal factor in the deterioration of Canada's national savings between the 1960s and 1980s was the shift from government net savings to government net dissavings, as measured for all governments combined.

Theory, general observations, and empirical studies all suggest that gross fixed capital formation and the stocks of capital were essential. The fact is that a positive correlation existed between investment effort and productivity and economic growth over the long run. Moreover, in all theories of economic growth it is invariably argued that investment is necessary to improve both potential and actual productivity growth. Thus high levels of investment were (and are) a *necessary* but not sufficient condition for productivity and economic growth.

A fundamental lesson of the past concerns the quality of investment and how physical capital interacted with the other major factors bearing on productivity and economic performance. There are open questions relating to the pace of innovation and the appropriate mix of capital formation in the postwar period. Crucial was the way in which physical capital interacted with the other economic factors, such as the development of human capital, R&D activity, the quality of past investments, and the performance of Canadian financial markets.

2) ***Could stronger Canadian investment and/or savings efforts improve our future productivity performance and ability to realize other goals?***

The answer is yes, but several ways of responding to the question are suggested in this paper.

- First, there can be no doubt that some improvement in Canadian productivity growth performance is highly desirable to permit improvements in living standards and to enable possible solutions to many economic and social problems.

- Second, deterioration of Canada's investment and savings efforts would be counter productive. Investment efforts in the average range of the 1980s are barely sufficient to meet the needs of a growing population and labour force, and barely compatible with modest long-term productivity increases. Moreover, Canadian national savings efforts in the 1980s were not sufficient.

- Third, increases in Canadian investment and savings efforts could help to improve Canadian productivity, provided that they are part of a *multifaceted* effort to increase Canadian potential, innovations, skill development, capacity utilization, market access, and so on. The relative importance in Canada of the intangible innovation and other factors in total factor productivity growth lead to this view. More recent economic growth theories also serve to reinforce this point by stressing the significance of spillovers relating to investment and savings.

- Fourth, unidimensional efforts to increase investment by such means as subsidies, tax concessions, and inflationary finance appear unlikely to be successful. Canada's use of added investment incentives and broad-gauge research and development incentives in the 1970s and 1980s appear to have produced very limited real results.

It is clear that a good level of investment in fixed capital is necessary for good productivity growth in Canada. Canada's geography, climate, capital-intensive industrial structure, and population suggest the need for a greater investment effort than in many other industrial economies, although Canadian investment has only been about average. A better level of savings effort is required to control, and hopefully reduce, the increasing real burden of Canada's external debt service. Canada's private savings rates were persistently higher than those in the United States during the 1980s - a major factor in keeping the use of foreign savings less than it would otherwise have been.

3) ***Are additional investment and savings efforts essential to solving infrastructure problems, overcoming environmental degradation, achieving sustainable growth, reducing external debt, and meeting the needs of an aging population?***

Looking to the future, the answer appears to be yes for all these purposes. A number of factors point to the need for intensified investment and savings efforts.

Estimates of the range of future investment effort required in Canada were calculated, taking into account the desired rates of productivity growth, and the capital/output and capital/labour ratios. These estimates of future gross investment efforts range from a low of between 20.6 and 23 percent to a high of 26.9 percent of current GDP. All three estimates are predicated on productivity increases consistent only with the sluggish levels of the last decade. They do not put Canada on a growth path as high as that of the golden postwar years. Moreover, these estimates do not consider any

significant changes in the quality of capital resulting from technological change and innovation.

Despite these modest assumptions, the middle and the high estimates seem optimistic in terms of Canada's historical investment, which averaged a bit above 23 percent between 1955 and 1980, and under 23 percent in the 1980s. The low estimate appears unacceptable since it allows for labour force and productivity growth below the levels found in 1988 and 1989, which were the lowest in the decade. However modest the productivity estimates underlying this analysis, it is clear that relatively small increases in productivity growth require substantial future investment efforts.

The paper's examination of Canada's infrastructure, the environment, the required support of the aging population, and the external debt indicate that these are areas where further pressures for investment likely exist. While quantitative estimates of the related investment needs are limited, those identified emphasize that a lot more investment and savings will be required in Canada for those activities. As Charles Schultze has suggested, however, it is appropriate to question these calculations constantly with reference to possible price adjustments and related market signals.

There is no one panacea for raising Canada's productivity and economic growth. A wide variety of measures are needed, and greater investment and savings will clearly be a part.

APPENDIX A
Concepts of Investment, Savings, Capital, Growth, and Productivity

CONCEPTS OF INVESTMENT, SAVINGS, CAPITAL, GROWTH, AND PRODUCTIVITY

Investment Components and the Savings Identity

The investment most frequently examined in national accounts is in structures and machinery and equipment, which are used directly or indirectly in the production of goods and services. This investment in inanimate objects, together with investment in residential housing, is measured similarly in the national income and expenditure accounts of most countries. A distinction is often made between investment carried out by government, government enterprises, and the private sector. The measures may be gross (all new expenditure during a period) or net (new expenditure less an estimate of depreciation from the existing capital stock). If measured gross, the national accounts usually also include an estimate of depreciation as a separate item.

In any period, gross investment adds to the accumulated stock of capital, while depreciation and discards reduce the stock of capital. In most years, gross investment exceeds depreciation and discards, so that net investment is positive and the stock of capital is growing.

The productive capacity of a stock of capital may grow faster or slower than indicated simply by gross investment minus depreciation. New plant and equipment may be more productive than that being replaced. On the other hand, events may make some existing plant and equipment less productive. For example, the sharp increases in energy prices in the 1970s made some older, energy-inefficient plant and equipment uncompetitive.

In a closed economy (e.g. the world), investment during a period requires an equal amount of saving during that period. Investment can only be made if some productive capacity is not used to meet private and government consumption during the period. The income and productive capacity not used to meet consumption are, by definition, savings during the period.

For any individual country, investment in that country during a period may be more or less than savings, since the country can be a user or supplier of savings from or to the rest of the world. In recent years, for example, Japan and Germany were net suppliers of savings to other countries; the United States, Canada, and Australia were net users of the savings of other countries. In principle, however, the net use and supply of savings balance for all countries together.

It is standard national accounting practice to measure, and include separately, the net new investment in business and government inventories. Net investment is positive if the value of the net change in the stock of inventories is positive; negative, if the stock is being drawn down. If investment totals during a period include the change in inventories, then the savings measures have to be compatible. The national and international compatibilities of savings and investment hold, with the appropriate statistical adjustments.

Consumer Durables

Less frequently, the stock of capital also includes consumer durables. These goods are added to and used up much like producers' plant and equipment. In principle, they are valued for the services they provide over time, in the same way that producers' plant and equipment are valued. If consumer durables are included in the stock of capital and in measures of gross and net investment, appropriate adjustments have to be made to the measurement of savings. When this is done, the savings-investment identities, appropriately redefined and measured, continue to hold.

The reluctance to lump consumer durables into the stock of capital arises from ambiguities in their status and imprecision in measurement. The services from consumer durables are complex and difficult to measure. Until fairly recently, they were mainly non-market transactions. Also, they can be considered separately in economic analysis and forecasting.

Human Capital

The concepts of capital, investment, and savings can also be extended to human capital. Education and skills can contribute to investment. Development of human capital requires savings, in the sense of not using income and productive capacity for other purposes. The stock of skills can be depleted by retirements and deaths; by changing technology, which renders certain skills redundant; and by poorer health of the work force. The stock can also decline if schools and training deteriorate so that those entering the work force are less skilled than those leaving it.

The complexities and concepts of dealing with human capital are very different from those arising for inanimate capital. Thus it is usually better to deal with human capital issues as a separate, though related, concern when studying growth and productivity.

Intellectual capital in the form of patents, plans, and accumulated knowledge of products and processes is not included, in whole or in part, in investment and capital in standard national accounts. Some, but not all, of the activities relating to intellectual capital are included in the costs of plant and equipment. Similarly, the costs of market

developments are not included in conventional measurements of capital. Yet these activities are important to the performance of a national economy.

Measurement and Comparison Problems

Returning to the standard definition of capital,[35] measurements of the stock of capital can be built from the record of gross investment expenditures, depreciation and discards, and the value of changes in the physical stock of inventories. For most countries the estimates have been based on applications of the perpetual inventory methods developed in the United States after the Second World War by Raymond Goldsmith. Data on gross additions to the stock are reliable, but problems arise in determining the appropriate estimates for depreciation and discards, plant life, and adjustment for price variations.

Estimates of the stock of capital have been developed during the last 30 years for many developed countries, some of them extending back to the early 1900s. In turn these have been used in growth analysis, in various combinations such as average and incremental capital/output ratios, capital/labour ratios, capital/productivity estimates, and so on [see, for example, Maddison (1979, 1980, 1984); OECD, *Flows and Stocks of Fixed Capital*, various issues; Kindleberger; Harrod; Domar (1946, 1947); Solow (1956), and Meade].

Estimates for Canada were made by Hood and Scott for the Gordon Commission, later revised and continued by Statistics Canada. Urquhart has built up a historical series to extend the official estimates back into the nineteenth century. The official Statistics Canada estimates of the stock of capital were extensively revised in the late 1980s and the constant-dollar figures were rebased on 1986.

Recently Michael Jaffey of Statistics Canada showed that Canada's cumulative stock of capital had been overestimated during the last 15 years. That is because plant and equipment lives were overestimated; discards, underestimated.[36] Jaffey's argument and general observations suggest that the overestimation of both the gross and net capital stock may be quite large. For telephone utilities, for which a good body of data is

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[35] The standard definition of "capital" is private and public plant and equipment, residential housing, and business and government inventories.

[36] Jaffey's experimental empirical application of his model is to the telecommunications industry. For it, the reduction in plant lives and the increase in the rate of discarding have been large. Accordingly, the overestimation of capital stock in that industry by the traditional methods has been large. Jaffey has expressed the view that the overestimation in many other industries will probably turn out to be less than for telecommunications because of the observed higher rates of technological improvement in that industry than, on average, over the whole economy.

available, he suggests that the traditional methods and assumptions may overestimate the gross stock by more than 40 percent and the net stock by more than 60 percent. Jaffey's suggestions were not introduced into the revisions in the stock of capital made in the late 1980s by Statistics Canada.

The Impact of Re-estimating Depreciation

The upshot of Jaffey's argument is that the gross and net stock of capital available for use in Canada by the mid-1980s was significantly less than that previously estimated. The implication in productivity analysis would be a boost in the estimated marginal productivity of capital, a reduction in the marginal productivity of labour, and a reduction in the growth resulting from technological progress. Total factor productivity measurements would be larger too.

Since most western industrialized countries have used the same methodology and types of assumptions as Canada in measuring their stocks of capital, Jaffey's critique probably applies in a similar way to them as well. Thus, the application of Jaffey's method may not bring about qualitative changes in international comparisons.

APPENDIX B
The Theory of Capital Formation, Economic Growth, and Productivity

THE THEORY OF CAPITAL FORMATION, ECONOMIC GROWTH, AND PRODUCTIVITY

Every respected theory or explanation of economic and productivity growth includes capital accumulation, or investment, as a necessary but not sufficient condition for growth. Some theories focus on capital accumulation by itself. More often, it is viewed as one of several related and interdependent factors, including enterprise, innovation, and technical change.

Resources, labour, existing capital, and potentially usable knowledge - the factors analyzed by traditional capital theory - define, in some sense, a set of opportunities. By themselves, however, they clearly do not determine when those opportunities will be seized or the rate at which they will be exploited. Traditional capital theory, therefore, provides only a partial catalogue of the incentives to invest. It provides no explanation for the gap between the potential and the effective productivity of capital.

Determinants of Growth

At the proximate level, many factors determine whether potential economic growth (including the potential productivity of labour, capital, resources, and knowledge) is realized. In this regard, among the factors given prominence in respected theories of growth are:

- enterprise;
- the appropriateness of the structure of the stock of capital (mix, durability, efficiency, and the matching of it with preferences in production and consumption);
- flexibility and adaptability to changing circumstances and needs;
- resource allocation within economies, particularly between agriculture and non-agriculture and between goods and services;
- the degree of buoyancy and stability of demand;
- the openness of markets - in particular, internationally;
- taxation and incentive programs;
- regulation; and

- effectiveness in bringing social returns into operation when they are different from private returns.

Some theories of economic growth and productivity examine the determinants on more fundamental levels. What are the determinants of capital formation? Why does it change? Why is the usable resource base what it is? And so on.

For capital formation these more fundamental analyses focus on the relationship of profits and wages, on the record and expectations of profit, on taxation, and on the abundance or scarcity of saving. Marxian theory and its successors put at the centre of growth theory the capitalist struggle to preserve profitability in the face of diminishing returns to capital accumulation and the pressure for increased wages. In his approach to growth and cycles, Schumpeter built in waves of innovation, of leadership and copying, of creative destruction, of temporary advantages, and of long periods of more- and less-rapid economic growth. Rostow insists that growth has to be analyzed on a micro basis. From time to time, some conjuncture of knowledge and circumstances leads to major increases in productivity and growth in a few industries, creating a take-off for an economy, which is followed by a drive to technological maturity.

It is a main theme of this paper that when examining an economy or sector at some level of aggregation, modern adaptations of neoclassical growth theory are the most useful models - those attributed to Abramovitz; Solow; and, in Canada, Helliwell. An important implication of these theories is that increases in savings, or changes in government policy, have mostly transitory effects on economic growth. In a strict neoclassical model, long-run productivity growth is essentially a function of an exogenously specified rate of technological change and is therefore largely insensitive to policy measures.

In order to understand the mechanics of the neoclassical model, consider a once-and-for-all increase in the economy's output (as a result of trade liberalization, for example). This increase will then lead to an increase in the amount of savings in the economy. These savings will be invested in physical capital, thereby increasing output even further. The existence of diminishing returns to capital ensures, however, that capital accumulation will not go on forever; it will adjust, so as to keep the stock of capital per capita at its equilibrium level. But if we abstract from technical change, this means that *there is no long-run growth per capita*. The savings rate affects the long-run *level* of per-capita income, but not the growth rate. Every shock to the system is eventually dampened, as self-correcting forces bring the economy back to a long-run (or steady-state) equilibrium.

The usual way that neoclassical models account for the fact that each generation can expect to be much better off than the previous one is to include an exogenously specified rate of technical change. This implies that in the long-run steady-state

equilibrium, the economy will grow at a rate strictly proportional to that of technical change. This has come to be known as the "balanced" or steady-state growth path. Differences between actual growth paths and balanced growth are then due to *transitory differences* in capital accumulation.

These neoclassical models are very useful in clarifying the relationship between capital accumulation and growth and in distinguishing between growth and level effects. As a practical matter, however, the theory has to be leavened with a goodly measure of history and policy analysis.

More recent adaptations of neoclassical growth theory dwell on the interplay between the development of exploitable new knowledge and increasing returns to scale. By explicitly analyzing the incentives of workers to accumulate human capital and the incentives of firms to undertake R&D and introduce new products, they endogenize the rate of technological change. Some of these new theories suggest that savings and investment can make a much greater contribution to productivity growth than most neoclassical economists believe possible. Government policies can also significantly influence the long-run rate of growth. It should come as no surprise, however, that there is less agreement among the new theories on the subject of optimal government policy than there is on the positive aspects of growth.

Determinants of Potential for Growth

As stated above, most theories of economic growth distinguish between the *potential* for economic growth and the effective *realization* of the potential.

At the proximate level, the *potential* for economic growth is attributed to the resources available, the quantity and quality of labour, the stock of capital, and the exploitable stock of knowledge. The various theories of economic growth differ widely in their views of the importance of each of these elements, but all consider capital to be a significant component [see Abramovitz; Rostow (1960); Lewis; Solow (1962); Schumpeter; Kindleberger; and Maddison (1979)].

One family of productivity analysis treats the variations in potential real output of an economy, or the various sectors of an economy, as a function of inputs of capital, labour, perhaps energy, and other resources, working through a production function that conforms to some long-term structural characteristics of an economy. Two commonly used concepts of productivity are generated from such models: (1) total factor productivity, which is a ratio of output per composite input unit of capital, labour, energy, and whatever else; and (2) productivity per employee or employee-hour, which is a ratio of output per employee or hour.

In any case, capital per worker or per capita is one of the driving forces of potential economic growth, for three reasons:

- The larger the stock of capital per worker, the larger the potential output per worker, because workers have more plant and equipment to use.

- Capital formation and renewal are the principal parts of the process of taking into use new and enlarged bodies of knowledge, and more-efficient methods of production. In other words, exploitable new knowledge is largely embodied in new plant and equipment.

- The development of the knowledge embodied in new plant and equipment can lead to beneficial spillovers of technology. This may make the social return to capital investment greater than the private return.

The second measure - output per hour or employee - is the easiest to understand but difficult to use, because increases in potential productivity depend on the quantity and quality of labour inputs, the capital/labour ratios and the quality of capital, and the pace and form of technological progress. The first ratio, that of total factor productivity, depends on how the inputs are combined (a difficult concept); but it is more explicit about the factors and processes by which potential productivity changes. With appropriate manipulation, the two measures of productivity can be reconciled.

APPENDIX C
A Brief Note on Productivity: its Significance and Measurement

A BRIEF NOTE ON PRODUCTIVITY: ITS SIGNIFICANCE AND MEASUREMENT

Productivity is not only one of the most important issues in economics, but one of the most confusing. While the importance of productivity in determining living standards is usually underemphasized in popular discussions of economic policy, questionable statistics on productivity often receive a disproportionate amount of attention by the business press and policymakers. Given Investment Canada's recent research on productivity, a brief note clarifying some of the issues related to productivity and its measurement might prove useful.

Why Does Productivity Matter?

Consider a nation with a closed economy that wishes to increase the living standards (i.e. consumption) of its population. There are three ways in which it could go about doing that. First, it could shift resources away from investment and towards consumption. Obviously, that would lead to an increase in current consumption at the expense of future consumption and employment, and would therefore be counterproductive in the long run. Second, it could increase the size of its labour force (i.e. reduce unemployment and encourage more people of working age to look for jobs). While that would lead to a permanent increase in consumption, continued increases would be limited by the population. There are only a limited number of people of working age; thus consumption would have to level off in the long run. Finally, the nation could increase the productivity of its workers. That is the only option that could lead to continuing increases in living standards.

Now consider the additional options available to a nation with an open economy. First, the nation could borrow from foreigners to increase its consumption; but, again, that would obviously be a temporary measure. Second, the nation could get foreigners to pay higher prices for its exports and then use the revenue to buy more imports. Short of coercion, however, the only way that that could be accomplished would be by producing products that are of higher quality at lower cost, which is another way of saying it should increase productivity. Hence, productivity growth is the only way in which a nation can keep increasing its living standards.

How Should We Measure It?

Unfortunately, the concept of productivity is often defined in different ways by different commentators. The most common definition is labour productivity, but total (multifactor) productivity is also used extensively in the academic and policymaking communities. Capital productivity measures output per dollar invested. It is not

normally used as a measure of a country's productivity performance for two reasons. First, it is quite volatile, easily affected by large investments and second, increases in output are normally attributed to the labour input.

The main advantage of using labour productivity is that it is easy to conceptualize and to measure. Labour productivity is simply the amount of output obtained for a given amount of labour input. Output is usually measured as value-added or GDP; labour input, as the number of employees or hours worked. Given that reliable estimates of hours worked are often hard to come by, the number of employed persons is used more frequently.

In many popular discussions, poor labour productivity performance is often erroneously attributed to lack of effort by workers. Such claims reveal a fundamental misunderstanding of the term's meaning, since labour productivity refers to the output obtained given a similar amount of labour effort. Labour productivity is therefore a function of two basic factors. The first is the amount of inputs, such as capital and energy, that are used along with labour in the production process. Other things being equal, a worker who uses a great deal of machinery to produce a given output will have a higher productivity than a worker who does not. The second factor is the efficiency with which inputs are used in the production process. A plant that is larger or that possesses superior technology or management skill is likely to have higher labour productivity. Government policies, such as tariffs that protect firms from foreign competition, are also important determinants of the efficiency of production.

Although increasing the amount of inputs used in the production process will increase labour productivity, doing so is costly. Capital can only be accumulated by putting aside current consumption, and using more natural resources requires the payment of exploration and extraction costs. For that reason, economists have sought to adjust labour productivity measures to take into account other inputs, thereby capturing underlying improvements in technology and organizational efficiency.

The most common measure of technological improvements is the growth of total factor productivity. Unlike labour productivity, TFP is based on a number of theoretical assumptions, many of which may be only approximations. Thus, while the only problem with labour productivity is the accurate measurement of output and labour input, TFP has the additional problems of accurate measurement of all other inputs and the requirement that the underlying theoretical assumptions be met. Its main advantage is that it isolates efficiency problems from problems related to the level of resource use.

In practice, total factor productivity growth is defined as the residual obtained after a weighted combination of inputs is subtracted from output. As James Markusen (1990) points out in an Economic Council background paper,

> Since it is a residual, a [total factor] productivity change can be due to a very wide range of factors. These include changes in the quality of the inputs or output, mismeasurement of the input or output levels, and especially variations in production scale and capacity utilization.

It is the last two factors (variations in production scale and capacity utilization) that violate TFP's theoretical assumptions and make it especially misleading in the short run. It has long been recognized that capacity is underutilized during a recession. More recently, new Keynesian economists have argued that there are increasing returns to scale in the short run, and the "new growth theorists" have argued that there are even long-run increasing returns to scale at the aggregate level. Economies of scale go hand in hand with imperfect competition, which is also assumed away in TFP measures.

It is possible to adjust total factor productivity measures for scale economies and variations in capacity utilization, but doing so is a formidable task. For example, a recent paper examining the productivity slowdown in the United States, Canada, and Japan used a simultaneous-equations econometric model to adjust for variations in scale, capacity utilization, and markups [see Morrison]. The author found that these three factors explain all of the TFP slowdown of the 1970s in the United States and most of that in Japan. Consequently, only in Canada was there a substantial decrease in the rate of technological change. Of course, these results are only tentative, but they do serve to illustrate some of the problems involved in interpreting productivity measures.

A more formal and mathematical treatment of productivity measurement follows:

Given a production function:

[1] $$Q = f(L, K)$$

where Q = *output*

L = *labour*

and K = *capital stock*

Labour productivity is defined as:

[2] $$LP = \frac{Q}{L}$$

Furthermore, the marginal product of labour is defined as:

$$[3] \qquad MPL = \frac{dQ}{dL}$$

In a competitive labour market, the wage rate, r, will be equal to the value of the marginal product of labour.

$$[4] \qquad r = \bar{P} \cdot MPL \ ,$$

where $\bar{P}$ = *the aggregate price level*

To calculate total factor productivity, assume a production function that exhibits constant returns to scale, such as the Cobb-Douglas, whose functional form is:

$$[5] \qquad Q = \gamma \cdot L^{\alpha} \cdot K^{1-\alpha}$$

where γ = the level of technology; and
α = the elasticity of output with respect to labour.

This form restricts the elasticity of substitution between capital and labour to unity.

Total factor productivity growth can now be obtained with some algebraic manipulation. First, take a natural log (ln) transform of equation [5]:

$$[6] \qquad \ln(Q) = \ln(\gamma) + \alpha \ln(L) + (1-\alpha)\ln(K)$$

Now differentiation of equation [6], with respect to time, yields rates of change:

$$[7] \qquad \frac{dQ}{Q \cdot dt} = \frac{d\gamma}{\gamma \cdot dt} + \alpha \cdot \frac{dL}{L \cdot dt} + (1-\alpha)\frac{dK}{K \cdot dt}$$

Rearranging equation [7] yields the rate of change of technology over time or total factor productivity growth:

[8] $$\frac{d\gamma}{\gamma \cdot dt} = \frac{dQ}{Q \cdot dt} - \alpha \frac{dL}{L \cdot dt} - (1-\alpha) \frac{dK}{K \cdot dt}$$

In order to analyze equation [8] in terms of labour productivity growth and total factor productivity growth, the expression should be simplified by removing terms with the output variable Q. This can be done through equation [4], as it allows for a substitution of Q by a function containing only labour productivity and labour.

Now taking equation [4], performing a natural log transform [9] and a differential with respect to time, yields labour productivity growth as a function of output growth and labour growth [10]:

[9] $$\ln(LP) = \ln(Q) - \ln(L)$$

[10] $$\frac{1}{LP} \cdot \frac{d(LP)}{dt} = \frac{1}{Q} \cdot \frac{dQ}{dt} - \frac{1}{L} \cdot \frac{dL}{dt}$$

Rearranging the terms now provides an expression for output growth:

[11] $$\frac{dQ}{Q \cdot dt} = \frac{d(LP)}{LP \cdot dt} + \frac{dL}{L \cdot dt}$$

Substitution of equation [11] into equation [7] yields the following expression:

[12] $$\frac{d(LP)}{LP \cdot dt} + \frac{dL}{L \cdot dt} = \frac{d\gamma}{\gamma \cdot dt} + \alpha \cdot \frac{dL}{L \cdot dt} + (1-\alpha) \frac{dK}{K \cdot dt}$$

Rearranging the terms now provides an expression for labour productivity growth:

[13] $$\frac{d(LP)}{LP \cdot dt} = \frac{d\gamma}{\gamma \cdot dt} + (\alpha - 1) \cdot \frac{dL}{L \cdot dt} + (1-\alpha) \frac{dK}{K \cdot dt}$$

The condition of labour productivity growth exceeding total factor productivity growth is expressed by the following inequality:

$$[14] \qquad \frac{d(LP)}{LP \cdot dt} > \frac{d\gamma}{\gamma \cdot dt}$$

Solving equations [13] and [14] reveals the necessary and sufficient conditions under which labour productivity growth exceeds total factor productivity growth, namely:

$$[15] \qquad (\alpha - 1) \cdot \frac{dL}{L \cdot dt} + (1 - \alpha) \frac{dK}{K \cdot dt} > 0$$

$$[16] \qquad (1 - \alpha) \frac{dK}{K \cdot dt} > (1 - \alpha) \frac{dL}{L \cdot dt}$$

$$[17] \qquad \frac{dK}{K \cdot dt} > \frac{dL}{L \cdot dt}$$

Therefore, labour productivity growth will exceed total factor productivity growth if, and only if, capital stock growth exceeds labour force growth.

To obtain total factor productivity growth it is necessary to estimate the coefficient α. First, take the partial derivative of the production function, equation [5], with respect to labour input:

$$[18] \qquad \frac{dQ}{dL} = \alpha \cdot \gamma L^{\alpha - 1} \cdot K^{1 - \alpha}$$

Multiplying both sides by L gives:

$$[19] \qquad L \cdot \frac{dQ}{dL} = \alpha \cdot \gamma L^{\alpha} \cdot K^{1 - \alpha} = \alpha \cdot Q$$

$$[20] \qquad \alpha = \frac{L}{Q} \cdot \frac{dQ}{dL}$$

Once again, with perfect competition the wage rate is equal to the value of the marginal product of labour, so that:

[21] $$\alpha = \frac{r}{\bar{P}} \cdot \frac{L}{Q}$$

[22] $$\alpha = w \cdot \frac{L}{Q}$$

where $w = \frac{r}{\bar{P}}$

w being the real wage rate.

This expression in [21] is the share of labour compensation in national income.

APPENDIX D
Trends in National Savings and Investment in OECD Countries, 1960-88

TRENDS IN NATIONAL SAVINGS AND INVESTMENT IN OECD COUNTRIES, 1960-88

Appendix D provides data from Dean *et al.*, covering trends in the OECD countries for the period 1960 to 1988. The authors' findings reported earlier in this paper were made in reference to Table D-1, "Net and Gross National Savings Rates, OECD Countries, 1960-88" and to Chart D-1, "Trends in National Savings and Investment Rates, OECD Countries, 1960-88".

Table D-1
Net and Gross National Savings Rates, OECD Countries, 1960-88

		Averages					
		1960-70	1971-80	1981-88*	1986	1987	1988
United States	Net	10.6	8.9	3.7	2.5	2.4	3.3
	Gross	19.6	19.5	16.1	14.7	14.5	15.1
Japan	Net	25.6	24.6	20.4	20.8	21.2	22.0
	Gross	35.0	34.4	31.4	31.9	32.3	33.2
Germany	Net	19.9	14.3	11.1	13.1	12.9	13.9
	Gross	27.3	23.7	22.2	23.9	23.6	24.5
France	Net	19.3	16.3	8.2	8.6	7.9	9.2
	Gross	26.3	25.4	19.8	20.0	19.6	20.5
Italy	Net	15.0	12.1	7.5	-	-	-
	Gross	21.0	19.2	15.6	-	-	-
United Kingdom	Net	11.1	7.7	5.6	5.1	5.3	5.2
	Gross	18.6	17.7	16.8	16.3	16.3	16.4
Canada	Net	11.3	13.3	9.4	7.0	8.5	10.5
	Gross	21.8	23.1	20.3	18.5	19.6	21.1
Austria	Net	18.2	18.0	13.1	12.7	13.1	14.8
	Gross	28.0	27.6	24.0	23.7	24.0	25.4
Belgium	Net	14.4	13.9	7.0	8.3	8.8	11.1
	Gross	22.6	21.8	15.7	16.9	17.1	19.1
Denmark	Net	17.4	13.3	6.6	8.3	7.5	7.3
	Gross	23.2	20.3	15.0	16.7	16.2	16.2
Finland	Net	15.7	14.2	10.3	8.7	8.6	10.8
	Gross	25.6	26.7	23.8	22.6	22.4	24.2

Table D-1
Net and Gross National Savings Rates, OECD Countries, 1960-88

		Averages			1986	1987	1988
		1960-70	1971-80	1981-88*			
Greece	Net	15.3	20.7	8.5	5.4	5.8	8.7
	Gross	19.7	26.2	16.5	14.3	14.6	16.8
Ireland	Net	12.0	13.1	8.6	8.1	10.8	10.9
	Gross	18.6	21.0	18.5	18.1	20.3	20.4
Netherlands	Net	19.9	16.4	13.3	14.2	12.2	14.6
	Gross	26.9	23.9	22.3	23.0	21.4	23.6
Norway	Net	16.1	14.0	15.2	10.6	10.8	10.4
	Gross	27.5	27.0	27.8	23.4	24.1	24.7
Portugal	Net	19.8	22.0	19.9	22.2	24.5	22.5
	Gross	23.9	25.6	23.5	25.6	27.8	25.9
Spain	Net	16.7	16.7	10.1	11.5	12.4	13.0
	Gross	25.5	25.0	20.6	21.7	22.1	22.8
Sweden	Net	16.6	11.7	5.8	7.2	7.3	7.8
	Gross	25.0	21.0	16.9	17.9	18.1	18.6
Switzerland	Net	21.2	19.4	20.6	22.3	22.9	23.7
	Gross	29.6	28.0	28.4	29.7	30.3	31.2
Australia	Net	13.6	10.9	4.8	3.8	6.8	9.9
	Gross	24.7	23.6	20.1	19.9	21.9	23.8
New Zealand	Net	14.2	15.0	14.0	14.8	12.5	13.8
	Gross	21.2	21.8	20.9	21.6	19.5	21.0
Average of above countries†	Net	14.6	13.5	8.7	8.2	8.2	9.3
	Gross	23.3	23.5	20.2	19.6	19.6	20.3

* For Italy, revised National Accounts data are available for the 1980s only. In order to consider a longer run of data and a sectoral breakdown, the earlier National Accounts estimates, which are available only up to 1985, have therefore been used, with data for 1981-85 appearing in the third column.

† Excluding Italy.

Source: Data from Andrew Dean; Martine Durand; John Fallon; and Peter Hoeller, "Saving Trends and Behaviour", *OECD Economic Studies*, no.14, 1990, based on OECD, *National Accounts*.

Chart D-1
Trends in National Savings and Investment Rates, G-7 and OECD Countries, 1960-88
(G-7 countries and OECD total)

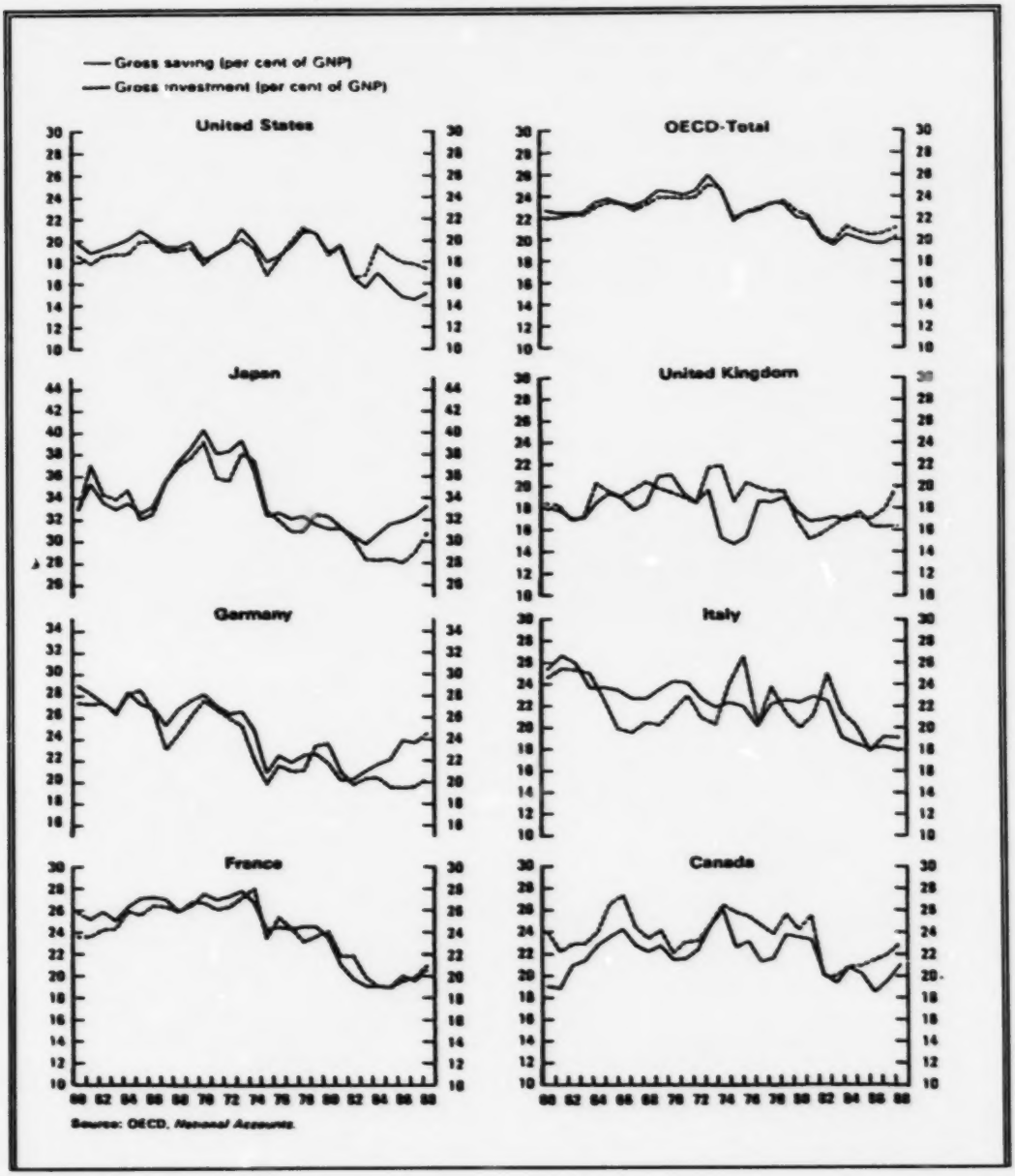


Chart D-1 (cont.)

(OECD countries)

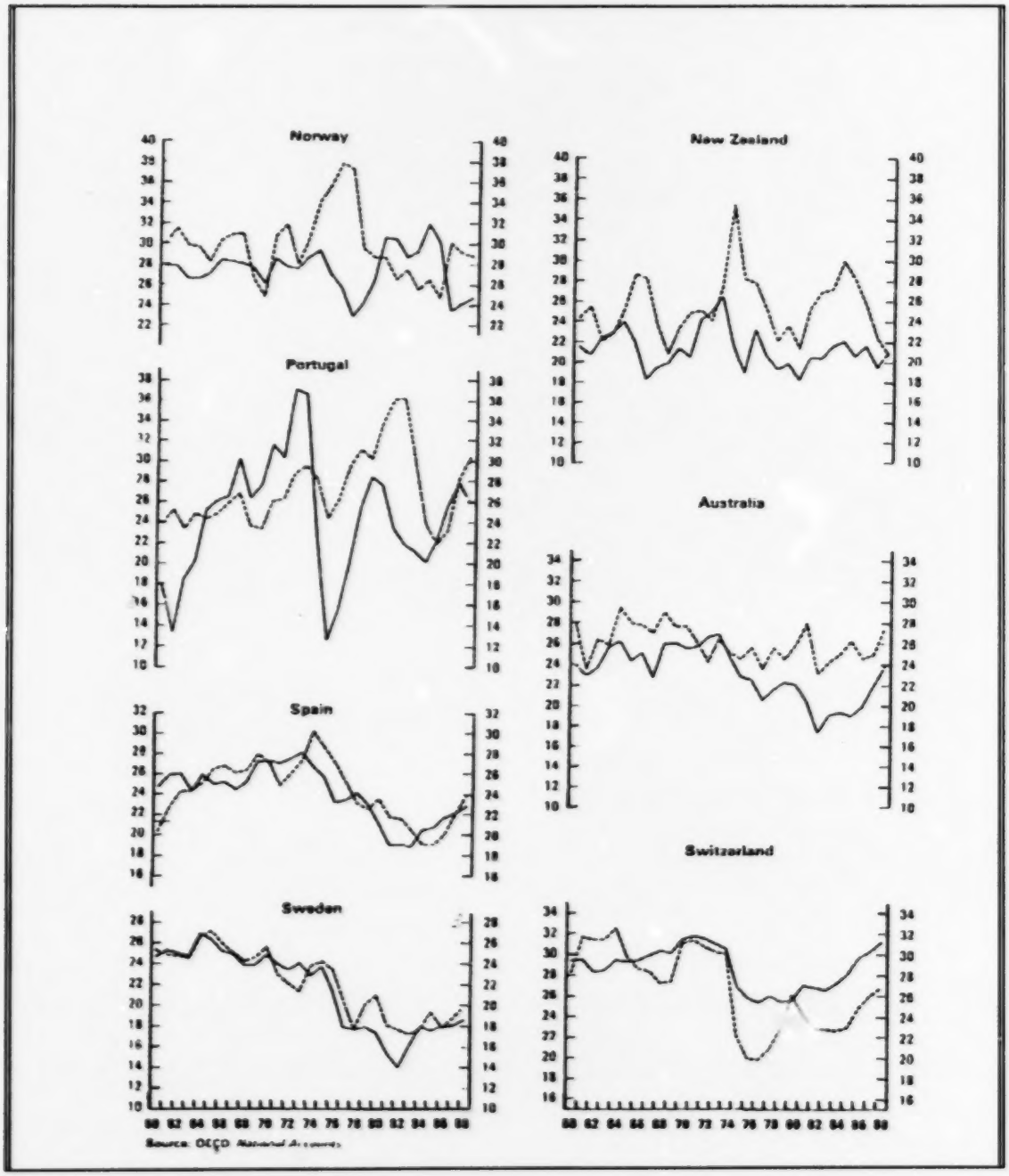
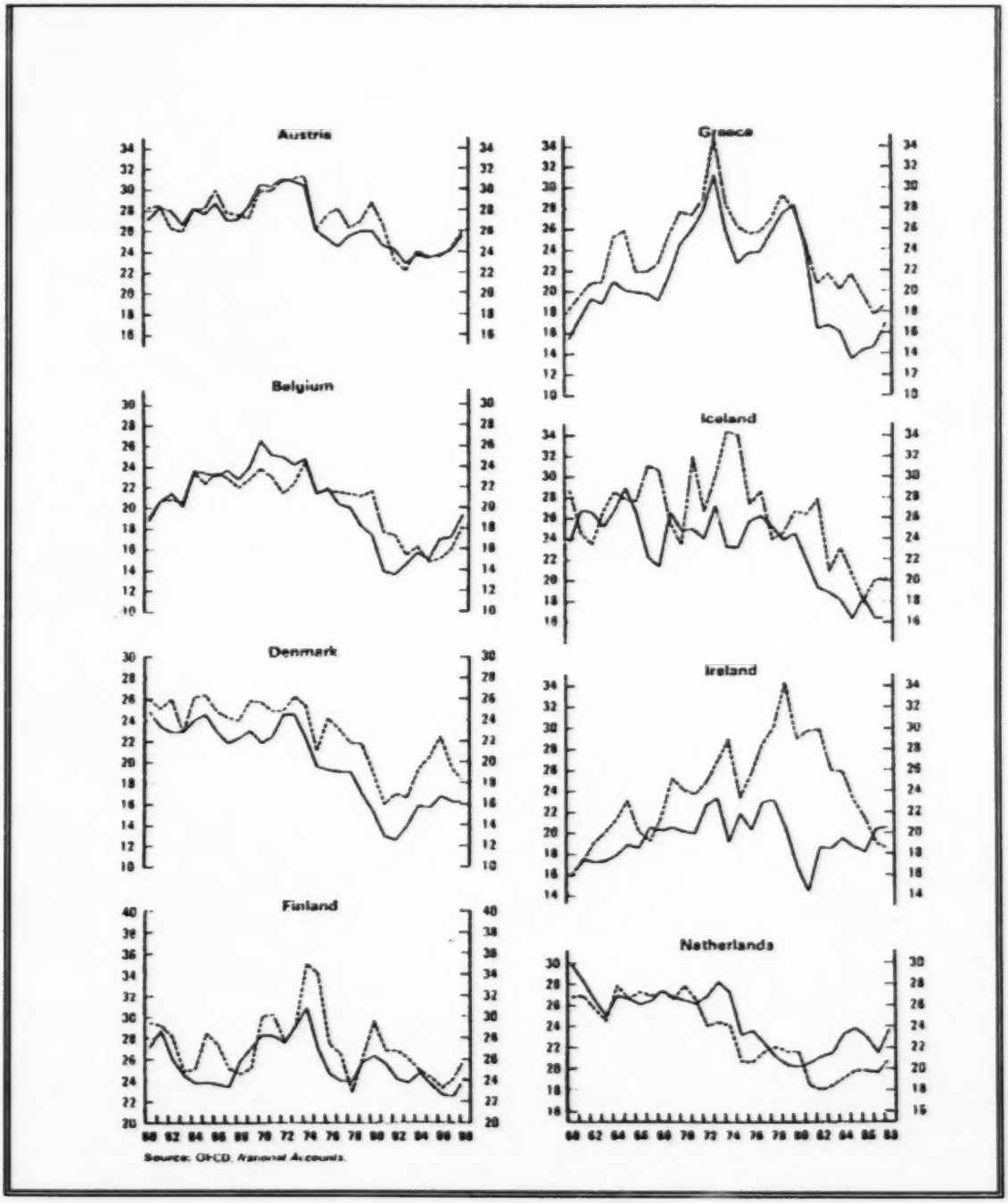


Chart D-1 (cont.)

(Rest of OECD countries)



APPENDIX E
Mathematical Note to Chapter 4

MATHEMATICAL NOTE TO CHAPTER 4

This Appendix provides mathematical details on the capital identity relationship in Chapter 4. It demonstrates that the incremental capital (expressed as a percentage of total capital) required under assumptions of changes in the labour force, increases in productivity, and increases in the capital/labour ratio is equal to the sum of the percentage change in labour, plus the percentage increase in productivity, plus the percentage increase in the capital/output ratio.

Given the following terms and identities:

K = *capital* $\qquad \frac{K}{L}$ = *capital / labour ratio*

L = *labour* $\qquad \frac{K}{O}$ = *capital / output ratio*

O = *output* $\qquad \frac{O}{L}$ = *output per worker (productivity)*

Capital may be expressed with the following identity relationship:

[1] $$K = L \cdot \left(\frac{K}{O} \cdot \frac{O}{L}\right)$$

From the above equation it follows that in order to hold productivity and the capital/output ratio constant while the labour force is growing, capital must be increased. With labour increasing, output must increase in the same proportion as labour to keep productivity from falling. In order to keep the capital/output ratio constant while output has increased, it is then necessary for capital to increase by the same proportion as labour. This is expressed by the following equation:

[2] $$\Delta K = K \cdot \left(\frac{\Delta L}{L}\right)$$

where ΔK is incremental capital.

It follows that if, in addition to the increase in labour, productivity increases, then output must increase to account for the increase in labour and the increase in the level of productivity. Consequently, capital would have to increase in order to hold the capital/output ratio constant. The percentage increase in capital equals the sum of the percentage increase in labour and the percentage increase in the level of productivity. This is embodied in the following equation:

[3] $$\Delta K = K \cdot \left(\frac{\Delta L}{L} + \Delta \frac{O}{L} \right)$$

where $\Delta \frac{O}{L}$ *is the percentage increase of the productivity ratio.*

Now if, in addition to increases in labour and productivity, the capital/output ratio increases, then it follows that the percentage increase in capital would be equal to the sum of the percentage increases in labour, productivity, and the capital/output ratio:

[4] $$\Delta K = K \cdot \left(\frac{\Delta L}{L} + \Delta \frac{O}{L} + \Delta \frac{K}{O} \right)$$

where $\Delta \frac{K}{O}$ *is the percentage increase of the capital/output ratio.*

Finally, assuming that the capital identity relationship, equation [1], is continuous, a first-order differential equation comparable to equation [4] may be derived as follows:

[5] $$dK = \left(\frac{K}{O} \right) \cdot \left(\frac{O}{L} \right) dL + L \cdot \left(\frac{K}{O} \right) d\left(\frac{O}{L} \right) + L \cdot \left(\frac{O}{L} \right) d\left(\frac{K}{O} \right)$$

[6] $$dK = K \cdot \frac{dL}{L} + K \cdot \frac{d\left(\frac{O}{L} \right)}{\frac{O}{L}} + O \cdot d\left(\frac{K}{O} \right)$$

[7] $$\frac{dK}{K} = \frac{dL}{L} + \frac{d\left(\frac{O}{L} \right)}{\frac{O}{L}} + \frac{d\left(\frac{K}{O} \right)}{\frac{K}{O}}$$

Equation [7] shows that the relative change in capital equals the sum of the relative change in labour, plus the relative change in productivity, plus the relative change in the capital/output ratio.

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